Number 32 Series 1926

UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF CHEMISTRY AND SOILS

In Cooperation with the University of Arizona Agricultural Experiment Station

SOIL SURVEY

OF

THE SALT RIVER VALLEY AREA ARIZONA

BY

W. G. HARPER, in Charge, F. O. YOUNGS, and A. T. STRAHORN
U. S. Department of Agriculture, and S. W. ARMSTRONG
and H. C. SCHWALEN, University of Arizona

▼

Beginning with the 1923 Series, Soil Survey Reports have been issued separately. The reports of the individual areas are sent to libraries as soon as they are available and should be filed, preserved, and ultimately bound to take the place of the bound volumes of the Field Operations which were formerly supplied by the department. The reports for each year are consecutively numbered, the last report for a particular year bearing the conspicuous notice: "This number is the last Soil Survey Report for the Year 192–."

For sale by the Superintendent of Documents, Washington, D. C. - - - - - - Price 25 cents

BUREAU OF CHEMISTRY AND SOILS

HENRY G. KNIGHT, *Chief*
A. G. McCALL, *Chief, Soil Investigations*
SYDNEY FRISSELL, *Editor in Chief*

SOIL SURVEY

CURTIS F. MARBUT, *in Charge*
M. H. LAPHAM, *Inspector, District 5*

COOPERATION

UNIVERSITY OF ARIZONA AGRICULTURAL EXPERIMENT STATION

J. J. THORNBER, *Director*
G. E. P. SMITH, *Head, Division of Agricultural Engineering*

CONTENTS

SOIL SURVEY OF THE SALT RIVER VALLEY AREA, ARIZONA

By W. G. HARPER, in Charge, F. O. YOUNGS, and A. T. STRAHORN, U. S. Department of Agriculture, and S. W. ARMSTRONG and H. C. SCHWALEN, University of Arizona

AREA SURVEYED

The Salt River Valley area is in the south-central part of Arizona in the eastern part of Maricopa County. It occupies a part of a large valley plain extending east and west of Phoenix, on both sides of Salt River.

The area surveyed covers 535 square miles or 342,400 acres, most of which is included under the Salt River irrigation project. Part of the land is now irrigated and on part of it irrigation development is under way. The lowest elevation is about 900 feet, that of the highest irrigated land is about 1,350 feet, and Camelsback Mountain, a part of which is included in the area, is 2,710 feet above sea level.

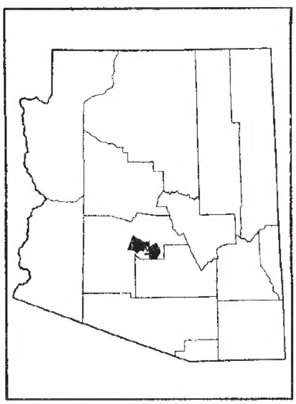


FIGURE 1.—Sketch map showing location of the Salt River Valley area, Ariz.

Salt River divides the area into two nearly equal parts. A strip of nearly level alluvial stream-bottom land ranging in width from a few hundred feet to a mile, parallels the stream channel. The rest of the area consists of a few low isolated mountain masses of small extent from which are spread out a series of alluvial fans and fan slopes. The smooth-surfaced higher fans are, in general, of uniform slope, but the grade differs in different parts of the area. Where the fans are near the mountains, the source of the soil-forming material, the grade is comparatively steep, averaging about 30 feet to the mile. Farther out on the fans the slope lessens but averages between about 15 and 20 feet to the mile. Comparatively high rocky hills and roughly eroded rolling fan slopes break the uniformity of the general terrain about 8 miles east of Phoenix.

The regional drainage of the area as a whole is very good. Surface drainage courses on the alluvial fans are not well defined, and following heavy rains the water flows over some of the lower areas and is carried away through artificial drainage and waste ditches.

Salt River receives much of the drainage of the area, and this stream, Gila River, and Paradise Wash, a tributary of Salt River, are the only well-defined drainage courses within the area. The rivers meander between uneven gravelly and sandy river-formed ridges and channels and change their courses from year to year. The main channels, most of which are dry during most of the year,

range from one-eighth to nearly a mile in width. These streams are comparatively shallow, cutting from 5 to 15 feet below the first bench land.

Maricopa County was organized from a part of Yavapai County in 1871. The total population of the county in 1920 was 89,576, of which 54,750, or 61 per cent, was rural. The population, however, has greatly increased since that census. The density of the rural population at that time was 6.2 persons to the square mile. Most of the inhabitants of the county live in the Salt River Valley area. About 75 per cent of the population is native-born white. The laborers are largely Mexicans, but many are native Indians from the reservations adjacent to the area.

Phoenix, in the west-central part of the area, is the capital of the State and the county seat of Maricopa County. Other cities and towns are scattered throughout the area.

The main line and several branch lines of the Southern Pacific Railroad System, a branch line of the Santa Fe Railway, and an electric line furnish transportation. Besides the rail facilities, auto stages run from the coast through Phoenix, Tempe, and Mesa to points east. Auto-truck transportation in the valley and to outside points is of importance.

There are about 350 miles of paved roads and highways within the area. The unpaved roads are well graded and many of them are macadamized or surfaced with gravel.

Most of the farmers in this area have established their homes on the farms. Electricity developed at the storage dams and power houses of the Salt River irrigation project is available on most farms, and telephones are in general use.

Produce is exported from the area to nearly all the large cities of the United States and Canada. New York, Chicago, Kansas City, Denver, and Los Angeles are the principal markets.

CLIMATE

The Salt River Valley area is in the arid Southwest. The climate is characterized by high maximum and mean temperatures, long hot summers and short mild winters, low annual rainfall, low relative humidity, rapid evaporation, and a high percentage of sunshine. The daily range in temperature is usually great. Even after hot days, the nights are generally cool.

The rainfall, though normally light, varies greatly from year to year. Prolonged droughts occur rather frequently. The mean annual precipitation at Phoenix is 7.87 inches. In average years most of the rainfall occurs at two distinct periods, in midwinter and in late summer. Thunderstorms, which are of comparatively little benefit to vegetation, are of frequent occurrence in late summer.

The mean annual temperature at Phoenix is 69.4° F. The frost-free season is long, averaging 292 days at Phoenix and 269 days at the Mesa Experiment Farm. The average date of the last killing frost at Phoenix is February 12 and of the first is December 1. However, frost has occurred as late as March 31 and as early as November 5.

Temperatures vary considerably in different parts of the area. The lower, flatter parts of the valley are much more subject to killing

frosts than are the higher foot slopes at the base of the mountains and the lands bordering the edge of the mesa north of Mesa. In such places air drainage is good, and for this reason winter temperatures do not drop so low, and citrus fruits are successfully grown without the use of orchard heaters. The wind velocity is not very high.

Table 1 gives the more important climatic data as recorded at the United States Weather Bureau station at Phoenix.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Phoenix, Ariz.*

[Elevation, 1,108 feet]

Month	Temperature			Precipitation		
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1885)	Total amount for the wettest year (1905)
	°F.	*°F.*	*°F.*	*Inches*	*Inches*	*Inches*
December	51.9	80	22	0.59	0.32	0.58
January	50.0	81	16	1.17	.00	3.31
February	54.4	91	24	.69	.47	4.64
Winter	52.1	91	16	2.45	.79	8.53
March	60.5	94	30	.49	.33	2.38
April	66.6	102	37	.43	.00	2.59
May	74.8	114	39	.03	.65	.04
Spring	67.3	114	30	.95	.98	5.01
June	84.4	116	49	.12	.04	.15
July	90.4	117	63	1.07	.18	.28
August	89.0	113	58	.96	.71	.92
Summer	87.9	117	49	2.15	.93	1.35
September	81.4	112	47	1.01	.07	1.23
October	70.2	105	36	.35	.09	.00
November	57.7	92	28	.96	.91	3.61
Fall	70.1	112	28	2.32	1.07	4.84
Year	69.4	117	16	7.87	3.77	19.73

SOIL SERIES AND TYPES

The area surveyed includes in part the area covered by a much earlier soil survey in this valley.[1] The southern boundary of the area joins, for a short distance, with that of a previous soil survey of the Middle Gila Valley which covers the Sacaton-Casa Grande-Florence districts on the south.[2] The earlier survey in the Salt River Valley was one of the earliest undertaken in the United States. Since that date most of the development in the science of soil classification and soil mapping has taken place. Owing to this and to the much more detailed character of the present survey, the soils delineated on the maps of the two surveys bear little relationship to each other, and there are many apparent conflicts in the soil classification. The more important differences in classification are noted under the descriptions of the respective soil series and types.

[1] MEANS, T. H. SOIL SURVEY IN SALT RIVER VALLEY, ARIZONA. U. S. Dept. Agr., Bur Soils, Field Oper. (1900) Rpt. 2: 287–332, illus. 1901.

[2] ECKMANN, E. C., BALDWIN, M., and CARPENTER, E. J. SOIL SURVEY OF THE MIDDLE GILA VALLEY, ARIZONA. U. S. Dept. Agr., Bur. Soils, Field Oper. (1917) Rpt. 19; 2087–2119, illus. 1923.

In soil classification, all soils are classed in major groups or series, largely on the basis of the character of the parent material and the stage of development or weathering which the soil has reached. The series may be further divided into soil types on the basis of the texture of the surface soil, that is, the proportion of different-sized particles present. In this survey, 37 soil types and 13 phases of types, representing 8 soil series, and 3 miscellaneous classes of material, river wash, rough broken land, and rough stony land, are mapped. A brief description of the soil series follows.

The soils of the Salt River Valley area are divided into two groups as follows: (1) Soils that have been developed from materials accumulated by the disintegration and decomposition of hard rock and which still overlie the rock from which they have been derived; and (2) soils that have been developed from rock débris that has been transported principally by water from its place of origin and deposited elsewhere. Soils derived from transported deposits are further divided into series according to color of the soil material and to differences in the profiles caused largely by the degree of aging or weathering that has modified the material following deposition. In the oldest soils of the valley the surface layers are leached of their lime and more soluble constituents. These materials have been carried down to the depth of water penetration or to a point at which they are deposited from solution. (Pl. 1.) The translocation of these materials and of the finer clay and colloidal materials gives rise to comparatively friable and lighter-textured surface soils with heavier-textured subsurface soils and subsoils, in many places having a mineral cementation. In the young or less modified deposits the weathering agencies have not greatly affected the soil profile which corresponds more closely to the characteristics of newly deposited strata of soil material.

The soils with the most fully developed regional profile have been grouped in the Pinal series. The typical surface soils range from a few inches to 2 or more feet deep and are pale reddish brown, pale pinkish brown, or rich brown in color. The surface soils grade downward into a slightly compact grayish-brown layer about 12 inches thick which overlies a fragmental or firmly cemented gray or pale yellowish-white lime-carbonate hardpan. The hardpan layer which extends to a depth of 6 or more feet is typically massive and impervious, but in many places includes lenses or masses of cemented gravel. Pinal gravelly fine sandy loam, with a stony phase, is mapped.

The Laveen series includes soils having a surface soil which consists of pale-brown, light grayish-brown, or pale reddish-brown gritty or rather fine-textured materials continuing to a depth ranging from a few inches to about 2 feet. Various quantities of small irregular lime-carbonate concretions or nodules are present in this layer, which is abruptly underlain by slightly compact material very high in lime and containing many lime-carbonate nodules. The lower part of this layer is grayish in color and consists of many loosely cemented lime-carbonate aggregates. The parent material lies at a depth ranging from 4 to 8 feet but averaging about 5½ feet. It is grayish-brown friable highly calcareous material but

does not contain the gray lime-carbonate concretions so characteristic of the weathered part of the soil profile. Laveen sandy loam, Laveen loam, with a gray phase, Laveen clay loam, and Laveen silty clay loam are mapped.

Soils of the Mohave series have friable or slightly compact surface soils of pronounced reddish-brown or distinctly red or dull-red color. To a depth ranging from 7 to 14 inches these soils are typically free of lime carbonate. Below these depths the soil material becomes somewhat redder in color, more compact, and of heavier texture, and free lime carbonate appears. The lime content increases with depth, and below an average depth of 30 inches the material is lighter grayish-brown, and gray lime mottles and a few small lime-carbonate concretions or nodules are present. The grayish-brown layer of high lime accumulation continues from a depth of about 30 inches to 54 or more inches, at which depth it is underlain by friable soil material very similar to the surface soil, but containing a moderate amount of free lime carbonate. Seven soil types of the Mohave series, the stony loam, fine sand, sandy loam, fine sandy loam, loam, clay loam, and silty clay loam, together with highly calcareous phases of the fine gravelly sandy loam and the fine gravelly loam, are mapped.

Soils of the McClellan series closely resemble those of the Mohave series but differ in having darker reddish-brown or chocolate-brown surface soils. The surface soils have resulted mainly from the deposition of silty sediments from muddy irrigation or flood waters. This deposit of silty material carries a small amount of lime which gives rise to a soil containing some free lime carbonate. Five members of the McClellan series, the loam, clay loam, silty clay loam, clay with a heavy phase, and clay adobe, are mapped.

Soils of the Tolleson series are very similar in profile to those of the Mohave series, but they have been affected by a high water table and accumulations of alkali. This condition has probably given rise to a slight yellowish tinge not present in the Mohave soils. The subsoils in many places are compact and tight compared with subsoils of the Mohave soils. Tolleson fine sandy loam, Tolleson loam, and Tolleson silty clay loam are mapped.

Soils of the Sunrise series are characterized by dark-brown surface soils which are similar in origin to the McClellan soils. Many small lime-carbonate nodules are present in the topsoil. The dark surface layer, which is largely a product of deposition from muddy irrigation water, ranges in thickness from a few inches to 2 or more feet. Beneath this layer is a moderately calcareous light clay loam layer, which also carries a few lime-carbonate nodules and which is underlain, at a depth ranging from 2 to 3½ feet, by an upper subsoil layer of grayish-brown compact clay loam containing gray mottles, streaks of lime, and many lime-carbonate nodules. This material, at a depth ranging from about 4 to 6 or more feet, grades into a brownish-gray heavy clay loam or clay firmly cemented hardpan which can not be penetrated with the soil auger. On drying, the material becomes very hard, but when moist, minute openings that allow the slow movement of moisture are noticeable and the hardpan crumbles or can be cut when struck moderately hard. The cemented hardpan may continue to a depth ranging from 10 to 15

feet, or strata of less firmly cemented material may occur between the various cemented layers. Sunrise clay loam and Sunrise silty clay are mapped.

Soils of the Cajon series consist of brown or light-brown highly micaceous materials of mixed origin. A typical 6-foot exposure shows a uniformly recent profile of friable mellow material of uniform structure and with no marked lime accumulation or development of zones of compaction. The lighter-textured soils of the series are commonly slightly stratified, whereas the heavier ones are almost free of stratification. The subsoils are generally of slightly lighter texture than the surface soils. These soils contain a small amount of free lime carbonate throughout. Eight members of the series, the fine sand; loamy sand, with a shallow phase; fine sandy loam, with a shallow phase; loam, with a red phase; silt loam, with a shallow phase; clay loam; silty clay loam, with a shallow phase; and clay, with a shallow phase, are mapped.

The Gila soils are recent stream-laid soils very similar to the Cajon soils but differing in a few respects. The surface soils are rich brown or pale reddish brown, are not so generally micaceous, and are in general more highly stratified. The subsoils are comparatively lighter textured. Six members of the Gila series are mapped: Gila fine sand, fine sandy loam, loam, with a poorly drained phase, silt loam, with a poorly drained phase, silty clay loam, and clay.

In the following pages of this report the various soils are described in detail and their agricultural importance is discussed; their distribution is shown on the accompanying soil map; and their acreage and proportionate extent are given in Table 2.

TABLE 2.—*Acreage and proportionate extent of the soils mapped in the Salt River Valley area, Ariz.*

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Mohave sandy loam	30,400	8.9	McClellan clay	5,248	2.8
Mohave loam	26,112	7.6	Heavy phase	4,352	
Mohave clay loam	15,808	4.6	McClellan clay adobe	1,920	.6
Mohave silty clay loam	17,664	5.2	Gila fine sandy loam	5,824	1.7
Mohave fine sandy loam	6,528	1.9	Gila loam	5,632	1.7
Mohave fine sand	3,136	.9	Poorly drained phase	512	
Mohave stony loam	2,560	.7	Gila silty clay loam	6,336	1.9
Mohave fine gravelly sandy loam, highly calcareous phase	6,976	2.0	Gila clay	4,736	1.4
Mohave fine gravelly loam, highly calcareous phase	1,856	.5	Gila silt loam	3,200	1.2
Cajon silty clay loam	13,568	7.7	Poorly drained phase	960	
Shallow phase	12,608		Gila fine sand	4,032	1.2
Cajon silt loam	13,056	6.3	Laveen loam	7,872	2.6
Shallow phase	8,704		Gray phase	1,088	
Cajon clay	4,096	2.9	Laveen silty clay loam	7,744	2.3
Shallow phase	5,952		Laveen sandy loam	1,536	.4
Cajon loam	9,472	3.6	Laveen clay loam	7,680	2.2
Red phase	2,752		Tolleson loam	2,432	.7
Cajon clay loam	2,752	.8	Tolleson fine sandy loam	1,984	.6
Cajon fine sandy loam	2,176	1.1	Tolleson silty clay loam	3,904	1.1
Shallow phase	1,600		Sunrise clay loam	6,720	2.0
Cajon loamy sand	2,304	1.1	Sunrise silty clay	4,672	1.4
Shallow phase	1,344		Pinal gravelly fine sandy loam	2,176	1.2
Cajon fine sand	576	.2	Stony phase	1,920	
McClellan loam	18,112	5.3	Pinal loam	2,304	.7
McClellan clay loam	19,200	5.6	River wash	8,512	2.5
McClellan silty clay loam	5,568	1.6	Rough broken land	2,944	.9
			Rough stony land	1,280	.4
			Total	342,400	

MOHAVE SANDY LOAM

The surface layer of typical Mohave sandy loam is light reddish-brown, dull reddish-brown, or brownish-red angular gritty material. The subsurface layer is of more pronounced reddish color. At a depth between 2 and 3 feet the soil becomes noticeably compact, heavier textured, and, owing to the presence of gray lime accumulations, more grayish. This layer of heavier material, which contains considerable lime and is weakly cemented, continues to a depth ranging from 4½ feet to 6 or more feet. At an average depth of 5 feet it is underlain by friable gritty material very similar to the surface soil. In the virgin condition the surface soil is slightly compact and absorbs only a part of the rainfall.

In areas of this soil on the fans that extend into the valley from Camelsback Mountain and the Salt River Mountains, the soil material is principally of granitic origin, whereas on the fans in the eastern part of the area, although largely granitic, it is of highly mixed origin. In the areas of nearly pure granitic material, the sharp angular particles present tend to cause the soil to pack and bake easily following irrigation or cultivation when very moist. Some of the areas included with this soil in mapping have rather dull-brown surface soils. Such soils represent a transition toward the related McClellan soils. This is one of the most extensive soils on the well-drained upland alluvial fans of the area. It occurs on very smooth-surfaced, gently sloping, uniform or very slightly rolling alluvial fans. Drainage is well developed, and nearly all the soil is free of accumulations of harmful salts. Under irrigation, however, underground seepage waters have approached the surface in a few places, owing to the imperviousness of underlying strata of clay or caliche. By means of electrically operated centrifugal pumps installed throughout the irrigated areas, the underground waters have been lowered and good drainage conditions have been artificially established.

This is a well-developed soil derived from transported water-laid sediments that had their origin either in near-by or rather distant mountain ranges. Following deposition, weathering agencies, principally temperature and rainfall, altered the soil profile by changing the position of the soluble and more easily movable material. The clay particles and the soluble minerals, chiefly lime, have been leached from the surface layers and deposited in the lower layers.

This is the most extensive soil in the area and is one of the most important agriculturally. Rather extensive areas are mapped on the high well-drained fans about Camelsback Mountain and the Salt River Mountains and on the ridges in the southeastern part of the area. Many bodies occur south, southeast, west, and southwest of Chandler. Virgin areas support a moderate growth of creosote bush, many cacti, and a few ironwood, mesquite, and paloverde trees. Following periods of appreciable rainfall, a 6-weeks' grass and (in the spring) some alfilaria spring up.

Nearly all the land is farmed. Alfalfa and cotton occupy the largest acreages, and grapefruit, oranges, and table grapes (pl. 2, A) are valuable and important crops produced in the more frost-free areas. Grains, olives, deciduous fruits, sorghums, sweetpotatoes, and

other commercial truck crops occupy smaller acreages. Oranges and grapefruit yield from 4 to 6 boxes to the tree, and grapes produce about 6 tons to the acre. Alfalfa hay yields from 2½ to 5 tons, cotton averages about two-thirds of a bale, and wheat yields about 18 bushels to the acre. Deciduous fruits yield well if given proper care.

Green-manure crops such as alfalfa, sour clover, and tepary beans are grown between the rows in some grapefruit and orange groves and in the vineyards. Commercial fertilizers are also applied to these crops. The use of commercial fertilizers is still in an experimental stage and the most profitable mixture has not been determined.

MOHAVE LOAM

The profile of Mohave loam is very similar to that of Mohave sandy loam but each layer is heavier in texture than corresponding layers in the sandy soil. The areas occurring north and east of Gilbert are redder than areas mapped elsewhere, some of which resemble soils of the McClellan series in the surface soil and subsoil layers.

Most of the Mohave loam lies adjacent to but lower than the lighter-textured soils of the Mohave series. It occupies the lower parts of old alluvial fans and is very smooth surfaced, gently sloping, and in most places well drained. Extensive areas occur south of Goodyear, where the soil lies between ridges; near Chandler, where it lies near or on top of the low ridges; and east and southeast of Mesa. Bodies are near Peoria, just south of Washington School, and northeast of Scottsdale. The gravelly areas near Peoria are shown on the map by gravel symbols. Drainage is moderately well developed. Nearly all the land is under cultivation and is intensively cropped.

MOHAVE CLAY LOAM

The profile of Mohave clay loam closely resembles that of Mohave sandy loam. The surface soil of sharp coarse gritty material ranges from a few inches to 2 feet in thickness. The grit, which is of mixed origin, consists chiefly of granitic and quartz coarse sand particles. The surface layer is brownish red or dull reddish brown with duller-brown mottles. The subsurface layer is of compact consistence, reddish color, and in most places gritty clay texture. At an average depth of 38 inches grayish mottles, caused by an accumulation of lime, become noticeable. In many places lime continues to a depth below 6 feet, but it generally decreases in quantity at a depth of 5 feet and at a depth of 6 feet is barely noticeable. Below this layer is the unaltered friable clay loam parent material, which contains a moderate proportion of lime carbonate.

In areas around Gilbert and those farther north and northeast of Gilbert, the surface soil and subsoil are slightly redder and slightly more compact than in other areas. A few bodies lie northeast of Peoria, east of Scottsdale, in the vicinity of Chandler, and northeast of Phoenix, and about 1½ miles southeast of Bell Buttes. A

few small areas contain waterworn gravel, ranging from fine gravel to stones 2½ inches in diameter.

Areas range from level to very slightly rolling. Surface and subsoil drainage are slow but not too slow to prevent adequate aeration and oxidation, which are favorable to root development of most field plants of the region. Nearly all this soil is under cultivation, principally to alfalfa and cotton.

MOHAVE SILTY CLAY LOAM

Mohave silty clay loam is very similar to Mohave clay loam but contains a higher percentage of fine smooth-textured materials that lie close together and reduce the amount of pore space.

This soil occurs on the old alluvial fan extending from the margin of the area east of Gilbert nearly to Gilbert. At and around Gilbert the body narrows and is broken by areas of lighter-textured soils which have merged from both sides. In the continuation of this slightly depressed area, about a mile west of Gilbert, the light-textured material terminates and the silty clay loam soil extends into the low rather flat area southwest of Mesa.

Drainage is very slow. Much of this soil within the Salt River irrigation project lies on comparatively low parts of the fan where seepage water has approached the surface. Pumps are keeping the water table below a depth which would be injurious to crops, and no high accumulations of alkali salts occur at present.

MOHAVE FINE SANDY LOAM

The surface soil of Mohave fine sandy loam consists of pale reddish-brown or rather dull reddish-brown fine sandy loam from a few inches to about 2 feet deep. The first few inches of this layer are leached of free lime where the soil is not cultivated, but where the surface soil and subsurface soil materials have been mixed through cultivation some lime carbonate occurs throughout the surface soil. At an average depth of about 20 inches the surface soil is underlain by compact reddish-brown or brownish-red heavy fine sandy loam or loam containing a few gray lime mottles. This layer extends in most places to a depth of 3½ feet, where it grades into pinkish-gray fine sandy loam high in lime carbonate. Below an average depth of 4½ feet, or rarely more, is friable sandy material very similar to the surface soil.

The largest area of this soil lies just west of Chandler. A few small areas occur in the same vicinity, and many elongated tracts are east and northeast of Chandler, where the soil occurs on ridges which have been built up by streams entering the area from higher desert lands to the east. Areas are moderately smooth and are only slightly rolling. Drainage is good or excessive in the surface soil and good in the subsoil.

All this soil is in cultivation, principally to alfalfa and cotton. Some dairy and truck farming are practiced. Alfalfa yields 3 tons and cotton from one-half to 1 bale to the acre. The soil is easily plowed and pulverized.

MOHAVE FINE SAND

The surface soil of Mohave fine sand is loose rich-brown fine sand slightly tinged with yellow or red. It is underlain at a depth ranging from a few inches to 2 or more feet by a layer of slightly more pronounced reddish heavy fine sandy loam of rather compact consistence. This layer is from a few inches to 2½ or more feet thick and grades into grayish or pinkish-gray material mottled with lime and containing, in many places, a few lime-carbonate nodules or concretions. The deeper part of the subsoil, which lies at a depth ranging from 3 to 6 or more feet, is grayish-brown friable material containing some free lime. The material in this layer varies in texture from fine sand to sandy loam or gritty loam.

The parent materials probably consist of old deposits carried by Queen Creek. The coarser undecomposed materials are of highly mixed origin and, owing to their transportation by water are well rounded. The surface soil has probably been in part deposited or shifted by wind from adjacent sandy alluvial areas. The surface is slightly ridged. The soil is rather leachy and is excessively drained.

Mohave fine sand occurs in a number of elongated tracts on ridges or hummocks northwest, south, and east of Chandler. Alfalfa, cotton, and some sorghums are grown. Alfalfa yields 2½ tons to the acre and cotton about one-half bale. The sorghums give fair yields. This is a decidedly easy soil to cultivate. As it is very leachy, it requires frequent efficiently distributed irrigations to produce good crop yields.

MOHAVE STONY LOAM

The pronounced reddish-brown surface soil of Mohave stony loam averages about 12 inches in thickness. Where undisturbed the surface layer is commonly leached of free lime. The entire soil carries a large proportion of stone fragments, most of which are angular and sharp edged. The surface soil is underlain by brownish-red compact gravelly and stony clay loam containing a few gray lime mottles and extending to an average depth of about 26 inches, where it is underlain by brownish-gray slightly compact gravelly and stony loam of high lime content. At an average depth of 4½ feet this layer, in turn, grades into a zone of similar-textured material, which contains very little lime. The soil is somewhat compact throughout, and in the zone of high lime accumulation the gravel and stones are coated with lime-carbonate crusts and are loosely cemented.

Northeast of Lehi is an area which is not typical of Mohave stony loam. Here the material has been transported a longer distance and the gravel and stone are well waterworn and rounded. The subsoil layers are less compact and do not contain so much lime as typical.

Typical areas of this soil occur on the high fans near or adjoining areas of rough stony land. The slope is moderate, averaging about 100 feet to the mile. The surface is smooth, but many areas are eroded by shallow intermittent drainage ways. In the higher positions on the fans or near the source of the material more stones and coarse particles are present than in the lower-lying areas.

About one-half this land is tilled. Its position high on the fans, where air drainage is good and comparatively little frost occurs, renders it desirable for citrus-fruit production. Grapefruit and orange trees and grapevines, mainly young plantings not yet in bearing, have been set out. As stones are a hindrance to cultivation, the large ones have been removed from the surface of the more stony fields. Under irrigation the loosely cemented layer breaks down and becomes soft. Water penetrates the soil readily and in a few places the land is somewhat leachy.

This soil is most extensive along the outer margin of the area or bordering rough stony land areas northeast of Phoenix. One patch is mapped 3 miles east of Phoenix, and several tracts skirt the margin of the area near the Salt River Mountains.

Green manures should be plowed under and heavy applications of barnyard manures made in areas devoted to citrus fruits and grapes as the soil is very deficient in organic matter.

MOHAVE FINE GRAVELLY SANDY LOAM, HIGHLY CALCAREOUS PHASE

The surface soil of Mohave fine gravelly sandy loam, highly calcareous phase, to a depth of about 20 inches is pale-red, dull-red, or pronounced reddish-brown sandy loam or rather coarse sandy loam containing a large proportion of sharp angular fine gravel and coarse sand fragments. In the virgin condition the surface layer to a depth of a few inches is noncalcareous, as the lime carbonate has been removed through leaching, but where disturbed by cultivation the surface soil is mildly calcareous. It is underlain by slightly compact similar-colored sandy loam containing fine gravel and sharp coarse sand fragments, a few gray lime-carbonate flakes, and small lime-carbonate nodules. At a depth of about 28 inches this material grades into gray loamy coarse sand softly cemented by lime. (Pl. 1.) This layer generally extends to a depth of 6 or more feet, but in some places the more friable gritty coarse sandy loam of the parent material is reached at a depth between 5 and 6 feet. The parent material is loamy and varies from moderately to highly calcareous.

The layer of lime accumulation and cementation approaches a lime-carbonate hardpan in character. When dry this hardpan is very hard to penetrate with the soil auger, but when wet it can be bored into slowly if much pressure is used. The finer plant roots enter this material though not so readily as in the similar layer of typical Mohave soils. The red upper subsoil layer of clay accumulation typical of the Mohave soils is less well developed or is absent in this soil.

Soil of this phase is mapped on the comparatively high old alluvial-fan slopes adjacent to granitic hills or mountains that are the source of the soil materials. The soil particles, having been transported but short distances, are very angular. The surface is very smooth, and the slope of areas is moderately gentle, averaging about 40 feet to the mile. Drainage of the surface soil is good and, though water does not move rapidly through the subsoil, subdrainage is sufficient to care for removal of seepage water caused by irrigation.

Four areas of this soil have been mapped. One large tract occurs near Camelsback Mountain, and a long area lies on the north side

of the Salt River Mountains. A small patch is 2 miles west of West Chandler, and another occurs in the extreme southeast part of the area.

Virgin areas of this soil are covered with a growth of creosote bush, some cacti, ironwood, paloverde, and other plants common to the well-drained soils of the area. (Pl. 2, B.) The soil has a wide crop adaptation and is utilized in the production of the various crops grown in the valley. On account of their comparatively frost-free positions, the area about Camelsback Mountain and much of the area about the Salt River Mountains are used in the production of citrus fruits and grapes. The soil is easily plowed and tilled, but the angular particles fit closely and cause it to pack.

MOHAVE FINE GRAVELLY LOAM, HIGHLY CALCAREOUS PHASE

Mohave fine gravelly loam, highly calcareous phase, is very similar to Mohave fine gravelly sandy loam, highly calcareous phase, but it has a heavier-textured topsoil. Soil of this phase occurs adjacent to soil of the lighter-textured phase but lies lower on the slope. It has a slope of approximately 30 feet to the mile. Two areas are mapped northeast and one east of Phoenix.

CAJON SILTY CLAY LOAM

The surface soil of Cajon silty clay loam consists of brown highly micaceous smooth-textured material ranging in thickness from 6 to 18 inches and averaging about 10 inches. This material is derived from rocks of mixed origin, most of which were probably dark colored. Below the surface soil, the material is not quite so dark, being light chocolate brown or light brown. It is commonly of slightly lighter texture than the surface soil, being either light silty clay loam or silt loam. In only a few places is any stratification noticeable to a depth of 6 feet. This soil contains a very small proportion of free lime carbonate. A moderate proportion of organic matter is present, the capillarity is high, and the soil retains moisture well.

The color of the topsoil in the two areas east of Scottsdale ranges from rich brown to slightly reddish brown and the subsoil is slightly more compact than in typical areas. In addition to the areas just mentioned, the soil occurs extensively near Glendale, Alhambra, and Tolleson. Two areas are along New River and three are near Goodyear. In each of these areas the soil is composed of materials that have been transported by water from rather distant places and later deposited where the streams decreased in velocity and carrying capacity.

This soil occurs on the comparatively low parts of the alluvial fans. It has a very smooth surface and a very gentle slope. Drainage is good throughout. A fair proportion of organic matter is present, and the water-holding capacity is very good.

This is an extensive and highly important agricultural soil. It is utilized principally for truck growing, but cotton, alfalfa, hegari, and corn are grown to a large extent. Lettuce produces an average of about 250 crates and cantaloupes about 200 crates to the acre. Good yields of cotton, alfalfa, and grains are reported. Poultry raising and dairying are carried on.

This is a heavy soil which forms resistant clods if allowed to dry after being plowed wet, but when cultivated under favorable moisture conditions it is easily worked to a desirable tilth.

Cajon silty clay loam, shallow phase.[3]—The shallow phase of Cajon silty clay loam is characterized by a surface soil similar to that of typical Cajon silty clay loam. At various depths between about 8 inches and 6 feet, it is underlain by older alluvial-fan soil material over which the more recent surface soil material has been superimposed. In general, the underlying old alluvial-fan material consists of reddish-brown gritty heavy loam or clay loam. This layer grades into more compact heavier-textured material mottled with lime and in many places carrying many lime-carbonate nodules. The subsoil typically conforms to that of the old alluvial-fan soils which occur adjacent to areas of this phase. Nearly everywhere the subsoils are markedly compact as compared with the typical subsoils of the Cajon soils.

Soil of this phase is extensive in the northwestern and southeastern parts of the area. Part of the tract in the Roosevelt water conservation district is cropped and part of it is now being leveled for irrigation. The entire area under the Salt River irrigation project is intensively cropped and cultivated. Statements regarding crops grown, agricultural practices, yields, land values, and recommendations given under the discussion of Cajon silty clay loam also apply to this soil.

CAJON SILT LOAM

The grayish-brown surface soil of Cajon silt loam extends to a depth of 8 or 10 inches, where it is underlain by slightly darker and heavier-textured material continuous to a depth of 6 or more feet. In other characteristics this soil closely resembles Cajon silty clay loam.

This soil is very extensive near Glendale, and tracts are mapped in the southeastern part of the area. The land has a very smooth surface and occupies gently sloping fans. Drainage is good. A few areas which have been used for several successive years in growing lettuce and turnips show signs of a very slight salt accumulation on the surface. Where gravity water is available, all this soil is intensively farmed. Lettuce, cantaloupes, alfalfa, and cotton are the principal crops produced. Hegari, corn, small grains, grapes, and deciduous and citrus fruits are grown with very satisfactory yields. Dairy and poultry raising are practiced. This is an easy soil to plow and pulverize and is valued highly for the production of truck crops.

Cajon silt loam, shallow phase.—The shallow phase of Cajon silt loam is characterized by a surface soil, ranging in thickness from about 8 inches to nearly 6 feet and averaging about 3½ feet, of material similar to typical Cajon silt loam. The subsoil consists of older alluvial-fan soil material over which the surface soil has been superimposed. The underlying material closely resembles the corresponding layers of the adjacent old alluvial-fan soils.

[3] The term shallow phase as used in this report has no reference to the thickness of the surface soil. It refers to the recently deposited alluvial-fan material from which the soils have developed. This is thinner in the phases described as shallow than in the typical soils.

The surface soil of this phase of soil has been formed by the deposition of silt from stream flood waters which have spread over the surface of the present fans. Ordinarily the surface layer in areas which join with the old alluvial-fan soils is shallow; it becomes deeper where this soil joins with typical Cajon soils. In most places the subsoil is similar to the upper part of the Mohave loam subsoil. In a few places east of Chandler where the soil joins areas of Mohave fine sand, Mohave sandy loam, Mohave fine sandy loam, Mohave clay loam, and Mohave silty clay loam the subsoils correspond to the upper subsoil layers of the adjoining soil.

This shallow soil occurs principally in the southeastern part of the area, but several tracts are in the northwestern part near Glendale. The relief is similar to that of typical Cajon silt loam, and drainage of the subsoil may be either slightly increased or impeded, depending on the subsoil texture and degree of compaction. Crops grown, methods of handling, land values, and recommendations described for typical Cajon silt loam apply also to soil of the phase.

CAJON CLAY

The surface soil of Cajon clay consists of chocolate-brown clay, ranging from about 6 inches to 3 feet in thickness, which contains a fair amount of organic matter and has a very high water-holding capacity. It is underlain by a slightly compact light chocolate-brown layer which in many places is faintly mottled with gray lime carbonate and which is underlain at an average depth of 3 feet by friable light chocolate-brown smooth-textured clay loam. The surface soil and lower subsoil layer are mildly calcareous, and the slightly compact layer is only moderately calcareous. This is a slightly weathered and modified soil which resembles in profile soils of the Anthony series recognized in other areas.

This soil occurs mainly in the vicinity of and south of Alhambra and near Tolleson. Two areas lie a few miles southwest of Tolleson and three occur along Agua Fria River. One of these areas, which is covered with a growth of rushes and has a high water table, is indicated on the soil map by marsh symbols. Most areas occur near the lower margins of recent alluvial fans, where fine materials, carried by the slower-moving flood waters which reach the flatter slopes, have been deposited.

Areas are exceptionally smooth and lie on uniform fans that have a slope of about 15 feet to the mile. Drainage is moderately slow. The abundant fine material present has a tendency to run together. Under irrigation the land absorbs water very slowly, but it has a high water-holding capacity and retains moisture well. This is a very difficult soil to handle unless it is cultivated under the most desirable moisture conditions.

Cajon clay, shallow phase.—The surface soil of Cajon clay, shallow phase, is similar to that of typical Cajon clay. It extends to a depth ranging from about 8 inches to nearly 6 feet, where it is underlain by a reddish-brown compact gritty loam or clay loam about 18 inches thick, which grades into compact gritty heavier-textured material highly mottled with lime-carbonate flecks and in places containing numerous lime-carbonate nodules. The subsoil

strata consist of weathered old alluvial-fan materials over which the smooth-textured clay material of the Cajon soils has been superimposed.

This soil occurs near and south of Alhambra, and south, north, and northwest of Tolleson. In surface relief, drainage, and consistence it resembles typical Cajon clay.

CAJON LOAM

To a depth of 6 or more feet Cajon loam consists of light-brown or light reddish-brown friable material of mixed origin that carries a small proportion of lime carbonate. A few small angular and rounded fine gravel and coarse sand particles are evenly distributed through the soil. In a few places lighter-textured or heavier-textured strata occur in the subsoil.

Several tracts of this soil are mapped in the southeastern part of the area in what might be termed the region of recent soils formed by Queen Creek. Four areas are mapped along Agua Fria and New Rivers, and many patches are included in the area of recent soils deposited by Cave Creek near Glendale and south of that place near Alhambra, and near Tolleson. One area lies southwest of Bell Buttes and two are at the margin of the area surveyed, north of Phoenix.

The area lying partly in sec. 8, T. 1 N., R. 2 E., and those occurring southwest of that section differ from other tracts of this soil in that they appear to consist of a mixture of material derived from the old alluvial fans and the typical soil material of Cajon loam. The surface soil is rich brown and contains a large quantity of angular granitic and quartz sand or coarse sand particles. Southwest of Bell Buttes an area consists of recent soil that has been formed by soil particles carried by flood waters from the higher parts of the fans and deposited on the lower parts. Here the material is almost wholly granitic, having had its origin in the granitic rocks of the Salt River Mountains. Much of the more easterly area north of Phoenix is composed of soil materials which have been transported a comparatively short distance, presumably from the near-by Phoenix Mountains. Here the surface soil to a depth of about 24 inches consists of brown friable material carrying many flat fragments of dark metamorphosed sedimentary rocks and a few subangular quartz particles. Between depths of 34 inches and 6 feet, the subsoil consists of brown material similar to that of the surface soil but slightly compact, faintly or moderately mottled with lime carbonate, and in places carrying a few lime-carbonate nodules. This area is similar to soils of the Anthony series recognized in other surveys.

Cajon loam occurs on slight ridges of smooth surface and very gentle slopes. Drainage is ideal. More than nine-tenths of the land is under cultivation to the crops commonly produced in the area. Truck crops, alfalfa, and cotton occupy the largest acreages. This is a very desirable agricultural soil.

Cajon loam, red phase.—The red phase of Cajon loam is very similar to typical Cajon loam in textural and structural profile but differs in color and character of material. The surface soil to a depth of 22 inches consists of friable mellow pale-red or slightly

yellowish-red gritty loam or sandy loam which is high in mica content and contains little or no free lime. Beneath this layer, the soil material contains a small proportion of free lime but otherwise is similar to the surface soil. The gritty material, which is coarse, angular, and not greatly waterworn, is principally of granitic origin. The deposit giving rise to this soil has been transported down the alluvial fans for comparatively short distances.

This soil is mapped on the eastern margin of the surveyed area, near Scottsdale parallel to Paradise Wash, and northeast of Phoenix. Very good yields of cotton and alfalfa are reported from the areas paralleling Paradise Wash, and excellent crops of citrus fruits, grapes, and olives are produced on the area northeast of Phoenix.

CAJON CLAY LOAM

To a depth ranging from a few inches to 20 inches Cajon clay loam consists of light chocolate-brown or rich-brown micaceous smooth-textured or slightly gritty clay loam, which is underlain to an average depth of about 3 feet by very slightly compact material faintly mottled in places with gray lime-carbonate flecks. The next lower layer consists of friable material similar to the surface soil and continuous to a depth of 6 feet. The soil material is mildly calcareous, in some places being moderately calcareous even in the compact layer.

The two areas mapped west and northwest of Alhambra vary from typical in that the surface soil and subsoil are free from angular grit. Tracts in the southeast part of the area also contain only a small proportion of gritty material.

This soil is mapped west, southwest, and south of Phoenix. A few small areas are south of Peoria. Bodies are comparatively low and are of recent alluvial origin. Areas are very smooth and gently sloping. Drainage is good.

CAJON FINE SANDY LOAM

The surface soil of Cajon fine sandy loam consists of brown or light-brown highly micaceous friable fine sandy loam or very fine sandy loam averaging about 10 inches in thickness. Beneath this is loose pale yellowish-brown fine sand, also highly micaceous, which continues to a depth of 6 or more feet. The entire soil carries a small proportion of free lime carbonate.

This is a recent alluvial soil and occurs on the comparatively high alluvial fans or where comparatively fast-flowing water has deposited the soil materials. The sand particles are of mixed origin and are well rounded.

This soil is mapped in the southeastern part of the surveyed area, near Alhambra, southwest of Glendale, and along Agua Fria and New Rivers. The areas in the vicinity of Alhambra and Glendale have heavier-textured subsoils than typical.

Areas are smooth and gently sloping, and drainage is good or excessive. Most of the land is under cultivation, chiefly to cotton, alfalfa, truck crops, and grapes.

Cajon fine sandy loam, shallow phase.—The surface soil of the shallow phase of Cajon fine sandy loam consists of layers similar to

Profile of Mohave fine gravelly sandy loam, highly calcareous phase

A, 2-year-old grapevines on Mohave sandy loam; B, virgin desert vegetation, mainly seguaro or giant cactus, on upper alluvial-fan slope occupied by Mohave fine gravelly sandy loam, highly calcareous phase

those of the typical soil but ranging in depth from 6 inches to 6 feet. At an average depth of about 3 feet the subsoil of this phase conforms to the surface soil of the adjacent old alluvial-fan soils over which the Cajon material has been superimposed. In general, the subsoil is a slightly compact 12-inch layer of loam underlain by more compact highly calcareous clay loam.

This soil is mapped near Goodyear and near the margin of the area northeast of Goodyear. The relief and surface drainage conditions are identical with those of the typical soil, but subsoil drainage is not so excessive. Approximately one-half the land is cultivated at present, chiefly to cotton and alfalfa. This is a warm soil well adapted to early crops, grapes, sweetpotatoes, and vegetables.

CAJON LOAMY SAND

Cajon loamy sand is very similar in most characteristics to Cajon fine sandy loam but is lighter in texture. The brown surface soil is underlain by slightly lighter-brown material commonly containing a few small rounded gravel of mixed origin.

This soil is most extensive east and west of Goodyear. Long comparatively narrow strips occur on the ridges that run roughly east and west in the direction of the streams which deposited the surface material. A tract in the northwestern part of the area along New River contains some gravel in the surface layer and is indicated on the soil map by gravel symbols. Another body containing gravel is mapped at the margin of the area about a mile north of Washington School.

This soil lies on very gentle slopes and has a very slightly undulating surface where it has not been leveled for irrigation. It is exceedingly well drained. About one-half of the land is irrigated and farmed at present, principally to cotton and alfalfa.

Cajon loamy sand, shallow phase.—This shallow soil differs from Cajon loamy sand in that the deposit of recent-alluvial material over weathered soil materials of the old alluvial fans is thinner, the underlying weathered materials occurring at a depth ranging from 6 inches to 6 feet but averaging about 3 feet. The subsoil closely resembles the surface soils of adjacent old alluvial-fan soils over which the Cajon material has been superimposed. In general it consists of mildly calcareous loam soil material overlying compacted highly calcareous loam or clay loam.

This shallow soil is mapped near Goodyear, east of Goodyear, and farther to the northeast. Where not leveled for irrigation the land is gently sloping and very slightly undulating. Small wind-formed hummocks about 12 inches high occur here and there on the surface. Surface drainage is excessive, and subsoil drainage is good.

Only a small proportion of this soil is under cultivation at present. It is planted to alfalfa and cotton, and comparatively fair yields are reported. The uncultivated areas support a sparse growth of desert sage, creosote bush, and a species of mallow.

Soil of this phase is very deficient in organic matter, which should be added if a permanent agricultural program is to be followed. Owing to its less pervious subsoil the shallow soil is not so leachy

as typical Cajon loamy sand. The land is well suited to the production of such crops as table grapes and early truck crops that require a warm early soil.

CAJON FINE SAND

Cajon fine sand is a recent-alluvial soil of mixed origin that is somewhat irregularly stratified. Owing to the irregularity of stratification the soil profile shows considerable variation. In typical areas the surface soil, to a depth of about 16 inches, consists of brown or light-brown loose highly micaceous mildly calcareous fine sand. Below this and continuing to a depth of about 30 inches, is a grayish-brown micaceous loose fine or medium sand layer containing a few small rounded gravel of mixed origin. Between depths of 30 and 38 inches the material is light yellowish-brown highly micaceous friable silt loam of thin platelike structure. This layer is underlain to a depth of 6 feet by loose grayish-brown sand containing considerable small gravel of mixed origin. The soil is mildly calcareous throughout.

Cajon fine sand is very inextensive, but areas of it are very distinctly defined. It is mapped in several small areas in the southeastern part of the area. One area is just south of Goodyear. An area of dune sand, occurring in the northeast quarter of section 17 and another a little more than one-quarter mile north of the center of sec. 16, T. 2 S., R. 6 E. have been included with this soil. The dunes are from 5 to 12 feet in height and are covered with a growth of sage and mesquite which renders the soil material rather stable and prevents the dunes from encroaching on the adjacent soils.

Cajon fine sand occurs on low ridges. The surface soil has been reworked to some extent by winds, which have left it slightly hummocky. The soil is too excessively drained to be well suited for irrigation without special irrigation methods. With the exception of the one small area south of Goodyear, none of the land is in crops. It supports a scattered growth of small creosote bush and some desert sage.

This soil is exceedingly low in organic matter. Under irrigation very short runs of water should be used.

M'CLELLAN LOAM

The surface soil of McClellan loam consists of rich-brown or light chocolate-brown slightly gritty material of mixed origin approximately 10 inches thick. This layer owes its origin to surface overwash of fine-textured sediments deposited from irrigation waters or from streams over an older and somewhat modified subsoil. The surface layer is underlain by a slightly lighter-textured reddish-brown layer that carries only a small proportion of free lime. This layer extends to an average depth of about 30 inches where it is underlain by a 10-inch layer of pronounced reddish-brown slightly compact heavy loam containing a moderate amount of free lime and a few rust-brown iron stains and mottles. This grades into brownish-gray compact slightly gritty clay loam, highly mottled with gray lime flecks and containing many lime-carbonate nodules about the size of buckshot. In many places this highly modified layer extends

to a depth below 6 feet but in most places at an average depth of about 5 feet it grades into grayish-brown friable light clay loam. This material contains moderate or large amounts of lime evenly distributed through the soil material.

In much of this soil mapped north of Phoenix the surface soil is similar to that of the adjoining Cajon loam. Here the surface soil is very friable and contains many small, flat, subangular rock fragments that have had their origin in the sedimentary rocks of the near-by Phoenix Mountains. In some of the areas in the vicinity of Phoenix, the brownness of the surface soil is due to the influence or admixture of soil material eroded from the Cajon soils. The areas near Peoria have been formed by deposition of materials by desert flood waters on gently sloping fans. Here the surface soil is of rather pronounced reddish color very similar to that of the Mohave soils. The areas about Cashion have a deeper surface soil than is typical, the compact layer lying at a depth of about 3 feet. The surface soil in the strip of this soil mapped in the city of Phoenix does not conform to type, having been altered and largely covered by foreign material incident to earlier occupation by Indians.

This is an extensive and widely distributed soil and is utilized in the production of a great variety of crops. It occurs in the city of Phoenix, a few miles north and on the ridges northwest of that place, in the vicinity of Cashion, and in the slightly ridged area about Peoria. Gentle slopes and low ridges with smooth surfaces are characteristic of the soil. Drainage of the surface soil and the slow subsoil drainage are a benefit rather than a detriment under irrigation where the conservation of water is important. Part of the area north of Phoenix is drained by electrically operated pumps, as the substratum prevents adequate downward movement of seepage water from irrigation.

All this soil is intensively cultivated, and nearly all crops grown in the area are produced to some extent on it. Alfalfa yields from 2 to 5 tons to the acre, average yields of grain are obtained, cotton produces from one-half to 1 bale to the acre, citrus fruits produce from 2 to 5 boxes to the tree, grapes yield from 8 to 12 tons to the acre, deciduous fruits yield well, and average yields of garden truck are obtained. The areas about Peoria and Cashion are cropped with alfalfa, grain, and cotton. Some dairying and winter pasturing are practiced near these towns. Citrus fruits and early spring truck crops are produced north of Phoenix where the soil occurs in a more frost-free belt. Some commercial fertilizers and green manures are used in the citrus groves.

This is a moderately easy soil to handle. When allowed to dry following a row crop, it packs and bakes to some extent and considerable power is necessary in plowing, but when moist it plows and pulverizes easily.

M'CLELLAN CLAY LOAM

The surface soil of McClellan clay loam is dull brown or chocolate brown in color, but in other respects it differs from McClellan loam only in its heavier texture. The amount of grit in the surface layer varies somewhat in different areas, depending largely on the amount and character of the sediments that have been deposited from irriga-

tion and flood waters and on the extent to which these sediments have been mixed by cultivation with the underlying gritty soil material. Many of the boundaries between this and other soils have been formed artificially by continued applications of muddy irrigation water and the consequent deposition of sediments.

This soil occurs in comparatively low-lying positions or on high alluvial fans where ditches, diverting water from Salt River, have distributed the turbid river flood waters. Areas are very smooth and very gently sloping or nearly flat. Drainage is slow. In some areas in which the deeper substrata do not allow adequate internal drainage the water table is kept low by means of electrically-operated pumps.

This is an important soil and is all under cultivation to alfalfa, cotton, grain, lettuce, cantaloupes, grapes, and garden truck. Dairy feeds are produced, and dairying is practiced to some extent. Alfalfa yields from 2½ to 5½ tons to the acre, cotton from one-half to 1 bale, grains from 15 to 50 bushels, lettuce and cantaloupes about 200 crates, and grapes from 8 to 12 tons.

Most of the surface soil of McClellan clay loam is high in colloidal material. Following row-crop production it has a tendency to run together and bake on drying. Although hard to plow when dry, the soil is broken down to a desirable tilth by disking, floating, and using clod-crushing implements.

M'CLELLAN SILTY CLAY LOAM

The characteristics of McClellan silty clay loam correspond very closely to those of McClellan clay loam. The surface layer is very smooth and carries only a small proportion of fine grit. This soil has been formed in much the same way as the clay loam and occupies similar positions. Drainage is rather slow.

McClellan silty clay loam is utilized mainly in the production of alfalfa, cotton, and truck crops. Alfalfa yields from 2½ to 5½ tons to the acre, cotton from one-half to 1 bale, lettuce about 200 crates, and garden truck does well. This is a heavy-textured soil that clods badly if allowed to dry thoroughly following plowing in a wet condition.

M'CLELLAN CLAY

The surface soil of McClellan clay is brown and in most other respects except texture corresponds very closely to that of the silty clay loam and clay loam soils of the McClellan series.

Most of this soil is mapped north and east of Phoenix. The surface layer is a product of silting from irrigation or flood waters. The soil occurs on the comparatively low smooth very gently sloping lands. Movement of water through the surface soil and subsoil is slow. A high water table was developed over large areas following extensive irrigation in the valley, but at present the water table is favorable and the land is generally well drained.

The principal crops are cotton, alfalfa, grain, and truck crops. Cotton yields from one-half to 1 bale to the acre, alfalfa from 2½ to 5 tons, lettuce and cantaloupes each about 200 crates, and grains yield well. The soil is high in colloids and becomes very hard when

dry. At times much of it is plowed when dry, but more often it is irrigated and plowed later when in the desired moisture condition.

McClellan clay, heavy phase.—The heavy phase of McClellan clay differs from typical McClellan clay in having a slightly darker surface layer which is almost free from grit but contains a greater proportion of clay. The thickness of the surface soil varies, averaging about 10 inches, but in a few places being as much as 2 feet. With the exception of one area mapped north of Glendale, soil of this phase occurs in strips paralleling Salt River in comparatively low positions, in most places joining the recent-alluvial soils along the river. A number of narrow gravelly areas paralleling the river on the south have been shown on the soil map by gravel symbols.

This land is smooth and very gently sloping or nearly flat. Drainage of the surface soil is sluggish and of the subsoil is slow. A high-water table has developed south of Tempe, but a comparatively small part of the soil as a whole is affected by a high-water table at present.

Land of this kind is utilized in the production of grain, Bermuda grass and seed, alfalfa, and cotton. Wheat yields from 18 to 40 bushels to the acre, barley from 20 to 50 bushels, oats from 30 to 60 bushels or about 2 tons of hay, lettuce about 200 crates, cantaloupes about 180 crates, alfalfa from 2½ to 5 tons, and cotton from one-half to 1 bale. Bermuda grass is grown for seed on an area southwest of Tempe and produces an average of about 300 pounds of seed to the acre. This is a heavy soil that must be plowed and tilled when in a favorable moisture condition.

M'CLELLAND CLAY ADOBE

The surface soil of McClellan clay adobe, to a depth ranging from 10 to 36 inches, consists of very dark-brown or dark chocolate-brown smooth material that runs together when wet and checks and cracks profusely and develops an adobe structure on drying. This is underlain by a reddish-brown clay loam layer that averages about 20 inches in thickness. Beneath this layer and continuing to a depth of 6 or more feet, is a light grayish-brown layer mottled with gray flecks and in most places carrying a few small lime nodules. This layer typically grades into compact rich-brown clay loam at a depth between 6½ and 7 feet. The surface material, like that of other soils of the McClellan series, consists of an overwash or deposit of sediments from muddy irrigation water.

The areas of McClellan clay adobe are mapped west and southwest of Phoenix. The subsoil in the more northerly part of the body at Phoenix is typical of the McClellan series but as the remainder of the soil borders the recent-alluvial bottom-land soils, the subsoils are influenced by and merge almost imperceptibly with subsoils of the Gila soils.

McClellan clay adobe has a very smooth surface. The soil occurs on very slight slopes, in nearly flat areas, or in slightly depressed swales. Surface drainage is very much restricted, and subsoil drainage is rather slow. Part of the soil is badly affected by alkali accumulations.

Cotton, grain, alfalfa, and truck crops are produced on areas which are free from injurious alkali accumulations. Cotton produces from

one-half to 1 bale to the acre, wheat from 18 to 45 bushels, barley from 20 to 50 bushels, and oats from 25 to 75 bushels, or 2 tons of hay. Alfalfa yields about 3 tons of hay to the acre, and truck crops produce heavily.

This is the most difficult soil in the area to cultivate and pulverize. Owing to its fine texture, however, it is highly retentive of moisture, and comparatively few irrigations and little water are necessary in the production of crops.

GILA FINE SANDY LOAM

The surface soil of Gila fine sandy loam to a depth of 10 inches consists of light-brown friable micaceous material of highly mixed origin. This is underlain by friable light-brown or slightly reddish loamy fine sand that becomes slightly lighter in texture with depth. Gravel is present here and there in the lower part of the subsoil. The soil is mildly calcareous throughout.

This is a recent-alluvial soil formed by deposition from comparatively fast-flowing streams. It occurs near the margins of the stream channels in a number of areas along Gila River and on both sides of Salt River. The relief ranges from hummocky and slightly rolling or ridged to smooth and gently sloping. The land is well or excessively drained.

Although no large areas of this soil are mapped, it is rather important in the production of some crops and is nearly all under cultivation. In the northeastern part of the area frosts are not severe and here a large part of the soil has been planted to citrus fruits. Grapes, potatoes, sweetpotatoes, and garden truck are grown, and good yields of these crops are reported.

Owing to its friability and mellowness this soil is easy to cultivate. It is deficient in organic matter and is generally slightly leachy. Short runs and frequent applications of water in irrigation are suggested.

GILA LOAM

The surface soil of Gila loam consists of chocolate-brown friable micaceous fine-textured material from a few inches to 2 feet thick. It is underlain by the light-brown or rich-brown micaceous unstratified or slightly stratified friable and, in most places, slightly lighter-textured subsoil. The soil is mildly calcareous throughout. The surface soil has good water-holding capacity and contains a fair amount of organic matter, but the subsoil is rather deficient in organic matter. The lighter-textured subsoils are more common from Tempe west than up the river from Tempe.

Gila loam occurs in the recent-alluvial bottoms along Salt and Gila Rivers. Areas are very smooth, and the average slope is only about 5 feet to the mile. Drainage is very good or slightly excessive.

This is one of the more extensive recent-alluvial soils along Salt River. Most of it is under cultivation. Various truck crops, cotton, alfalfa, grains, and tree fruits are produced with profitable yields. The soil is mellow, easily tilled, and well suited to irrigation farming.

Gila loam, poorly drained phase.—The poorly drained phase of Gila loam differs widely in profile and character of material from

typical Gila loam. The pale-reddish or yellowish-brown smooth-textured surface soil contains a small proportion of free lime. Below the surface soil, one or many strata of compact heavy clay may be present within a depth of 6 feet. In most places these heavy strata are high in lime, and in many places they are mottled with gray lime-carbonate accumulations.

Soil of this phase occupies a low poorly drained swale about 1½ miles northeast of Laveen. The heavy clay strata greatly retard good drainage and as a result the land is affected by high accumulations of alkali. A small part of the soil is being leached of salts in preparation for cultivation, but most of it is not adequately drained. It supports a growth of samphire, seepweed, jasmine, and greasewood.

Drainage and alkali reclamation of this land are feasible only following the installation of a drainage system that will keep the water table about 10 feet below the surface. The heavy clay layer causes slow water movement, which necessitates a long period of flooding to effect reclamation.

GILA SILTY CLAY LOAM

The surface soil of Gila silty clay loam, which ranges from a few inches to 2 or more feet in thickness, is brown or dull chocolate-brown material derived from mixed sources. At an average depth of 10 inches the surface soil is underlain by chocolate-brown slightly compact heavy silty clay loam or clay, which extends to a depth ranging from 18 inches to 4 feet where it, in turn, is underlain by friable light-brown loam or silt loam with a slightly yellowish or reddish tinge. The soil carries an even distribution of free lime throughout. It has a high water-holding capacity. The two surface soil layers, having probably been deposited from irrigation water, have been formed or built up slowly and organic matter has accumulated. As mapped, this soil includes some dark-colored areas which appear nearly black when wet and which are inclusions of the related darker-colored soil of the Pima series.

Gila silty clay loam occurs near the edge of the Salt River and Gila River channels. A few areas on the sides of ridges have been irrigated from canals following the crests of the ridges. The land has a smooth surface and a slope of about 6 feet to the mile. Surface drainage is slow, but subsoil drainage is very good. This is an extensive and important soil. It is all cropped, principally to truck crops, grain, and cotton, all of which are reported to give very good yields.

GILA CLAY

In profile, mode of formation, and occurrence Gila clay is essentially the same as Gila silty clay loam. The heavier texture of the upper soil layers is practically the only soil difference. Near Lehi areas of this soil have gravelly surface soils and subsoils and are shown on the soil map by gravel symbols.

This soil occurs in a number of areas near the banks of Salt River. The surface is very smooth, and the areas are slightly sloping or nearly flat. In some slight swales in a few places near Lehi underdrainage is impeded, and the underground water is held near the

surface. Pumps have been installed in such places. Although the water table is high, alkali salts have not accumulated to any great extent.

All this land is cropped, mainly to truck crops, grain, and cotton. Very good yields are reported.

GILA SILT LOAM

The profile of Gila silt loam corresponds closely to that of Gila silty clay loam except in texture of the upper two layers which are silt loam and light silty clay loam, respectively. The mode of formation, color, profile, occurrence, topographic features, and drainage conditions are similar to those described for Gila silty clay loam.

All this soil is under cultivation, principally to truck crops, grains, and cotton. Very good crop yields are reported. The soil is easy to cultivate, takes water readily, has a good water-holding capacity, and is well suited to irrigation farming.

Gila silt loam, poorly drained phase.—With the exception of surface texture the poorly drained phase of Gila silt loam is very similar to the poorly drained phase of Gila loam.

This soil occurs in only one area a short distance northwest of Laveen in a low swale where the slope is about 5 feet to the mile. The surface is slightly hummocky. Drainage is very poorly developed, partly on account of the compact clay layer which impedes natural drainage through the soil, and the accumulation of alkali is high. The land is not utilized in the production of crops at present but supports a growth of samphire, seepweed, and greasewood.

Although drainage is very slow, it seems possible that it could be improved and that leaching over a long period of time would free the soil of alkali salts, thus rendering it available for crop production.

GILA FINE SAND

The surface soil of Gila fine sand to a depth of about 12 inches is light-brown, uniform, highly mixed material high in quartz and mica. It commonly has a wind-laid structure of thin, parallel, horizontal layers. Below the surface soil, and continuing to a depth ranging from 4 to nearly 6 feet, the material is loose, slightly stratified fine sand. This layer, in turn, grades into a coarser-textured layer of sand and fine gravel, containing many large gravel or rounded stones of mixed origin in many places. The soil is mildly calcareous throughout. A few included areas have very fine sand surface soils.

Gila fine sand occurs close to the edge of or on islands in the large stream channels. Areas are mapped near and adjacent to areas of river wash along Salt and Agua Fria Rivers. The surface is characterized by many hummocks from 1 to 3 feet in height, which have been formed by wind.

Areas of this soil are irregularly cut by stream channels that have been formed during flood periods in the river. The land is too excessively drained to be of importance in irrigation farming. It supports a scattered growth of cottonwood trees, arrowweed, jimmy weed, and Bata Mote brush.

LAVEEN LOAM

The surface soil of Laveen loam is grayish-brown, pale reddish-brown, or pinkish-brown loam about 8 inches thick, containing much angular grit ranging in size from fine sand to coarse sand and consisting mainly of rock particles but partly of gray lime-carbonate fragments or nodules. The surface soil is loose and friable and pulverizes easily to fine granules or grains. It is underlain by grayish-brown or pinkish-brown slightly compact gritty clay loam or loam slightly mottled with gray lime accumulations and containing many angular lime-carbonate nodules. At an average depth of 2 feet this layer grades into gray or flesh-colored moderately compact gritty clay loam high in subangular or roughly spherical lime-carbonate nodules ranging from the size of a pinhead to about an inch in diameter. The high lime accumulations of this layer are somewhat segregated, and when a fresh cut in the soil is examined the brown soil particles and gray or almost white lime carbonate give a patchy effect. When dry, this material is very hard to penetrate with the soil auger and in many places resembles a fragmental hardpan. It extends to a depth of about 6 feet, where it is underlain by a more friable lighter-textured grayish layer of similar material but containing fewer lime nodules.

This is an old alluvial-fan soil derived from rock débris and rock fragments that have been transported from their place of origin and deposited by transient desert streams and flood waters. Following deposition, weathering and erosional activities have modified the soil profile.

This soil occurs in widely separated areas near the lower margin of the fan breaks near the point where the fans merge with lower-lying recent soils. Large areas are at Laveen, northeast of Mesa, and east of Scottsdale. The soil occupies gentle slopes, and it has a very smooth surface. Drainage is adequately developed.

With the exception of part of the area northeast of Mesa, which lies in the Roosevelt conservation district where only recently water has been available, all this soil is farmed. Cotton, which yields from one-half to 1¼ bales to the acre averaging two-thirds of a bale, is grown on the greater part of the land. Alfalfa yields from 2½ to 5 tons, wheat from 15 to 35 bushels, and barley from 18 to 40 bushels to the acre. Soil of this kind is easily tilled and handled under irrigation farming. No fertilizers are used at present.

Laveen loam, gray phase.—The gray phase of Laveen loam has a surface soil, ranging in thickness from a few inches to 2 feet, of gray loam which contains a great quantity of lime-carbonate fragments and nodules. The surface soil is underlain by a compact mottled and nodular gray clay loam layer which in most places extends to a depth of 6 or more feet, but which in a few places grades into less nodular friable light clay loam or loam at a depth below 4 feet.

This soil occurs near and on the breaks of old alluvial fans near Laveen, north of Mesa, and near Roosevelt School. Several narrow bodies lie northeast of Mesa, in association with the areas of typical Laveen loam and soils of the Pinal series. Such areas are generally underlain, at a depth of 4½ or more feet, by an intermittent true lime-carbonate cemented hardpan. Drainage is moderately well

12805 –31 —4

developed in most places, but in the bodies near the Pinal soils the intermittent hardpan obstructs internal drainage. The last-named areas occur in the Roosevelt conservation district and at present are not cultivated. Cultivated areas are utilized for cotton, grain, and alfalfa production.

LAVEEN SILTY CLAY LOAM

The surface soil of Laveen silty clay loam ranges from 5 to 24 inches in thickness, averaging about 8 inches. It consists of chocolate-brown rather smooth-textured material containing a few gray lime nodules or concretions. The surface soil is chiefly a product of deposition of fine sediments from irrigation flood waters. It is underlain by friable or very slightly compact light-brown clay loam which has a slight yellowish or pale-reddish tinge. This layer contains a few lime-carbonate nodules or concretions and is mottled with gray lime accumulations, the mottles becoming more pronounced with depth. At a depth of about 3 feet the material grades into grayish-brown or brownish-gray highly calcareous slightly or moderately compact clay loam containing many small lime-carbonate nodules and cemented fragments, and at an average depth of 4½ feet the layer of high lime concentration merges into a compact light brownish-gray heavy clay loam or light clay layer high in lime but containing no lime nodules or cemented fragments. In many places the lowest layer is streaked vertically or horizontally with gray or almost white lenses of lime accumulation.

This soil occurs in only one large and one small area southwest of Mesa. The land is smooth and slightly sloping. It occupies a comparatively low-lying part of the old alluvial fans. Drainage is rather slow, but by means of pumps the water table can be kept sufficiently low to allow irrigation water to drain away fast enough to prevent extensive high accumulations of alkali salts on the surface. Some parts of the soil containing appreciable quantities of alkali are indicated on the alkali map.

All this land is under cultivation, principally to alfalfa, cotton, grain, truck crops, and pasture grasses. Alfalfa yields from 2½ to 5 tons to the acre, cotton two-thirds of a bale, wheat from 18 to 40 bushels, barley from 20 to 60 bushels, oats 1½ tons of hay, lettuce about 200 crates, and Bermuda grass from 150 to 400 pounds of seed.

This is a heavy soil and, being high in colloids, it runs together and packs. It is very hard to plow when dry and is often irrigated just before plowing, then plowed when dry enough to scour well from the plow. Following plowing the soil is allowed to dry until the desired moisture condition for further working is reached.

LAVEEN SANDY LOAM

Laveen sandy loam corresponds very closely in profile characteristics to Laveen loam. The textures throughout various layers, however, are correspondingly lighter.

This soil occurs near the lower margins of old alluvial fans. Areas are rather smooth or very slightly rolling where the old fans

break off into the lower-lying lands. Drainage is moderately well developed, and no serious accumulations of alkali occur.

This soil is inextensive. Several tracts are mapped in the southwestern part of the area on the north side of Gila River, and several narrow bodies extend along or near the west margin of the old alluvial-fan soils in the western part of the area. Some of these areas which contain gravel are indicated on the soil map by gravel symbols.

The soil is extensively farmed. The principal crops grown are alfalfa, grain, and cotton. Alfalfa yields from 2 to 5 tons, wheat from 15 to 35 bushels, barley about 20 bushels, and cotton about one-half of a bale to the acre. On account of its friable consistence and gritty texture the soil is easily handled. It is plowed when dry, irrigated, and following drying of the surface soil is easily disked or harrowed into a desirable seed bed.

LAVEEN CLAY LOAM

Laveen clay loam except in its less silty surface texture, is very similar to Laveen silty clay loam. It occurs in only one large area in the vicinity of Mesa. It lies in a belt rather close to the lower margin of the old alluvial fan and in a lower position than the associated Laveen loam. The land is smooth and very gently sloping or nearly flat. Drainage is moderately well developed.

All this soil is intensively farmed to cotton; alfalfa; grains; truck crops, principally lettuce and cantaloupes; citrus and deciduous fruits; and grapes. Cotton yields about two-thirds of a bale to the acre, alfalfa from 2½ to 5 tons, wheat from 18 to 45 bushels, lettuce about 200 crates, cantaloupes about 185 crates, citrus fruits from 2½ to 3 boxes a tree (50 trees to the acre), and grapes about 5 tons. On account of its heavy texture, this soil requires a moderate amount of power in plowing. Considerable cultivation is needed to break up the clods if plowing is done when the ground is dry or if clods are allowed to form and dry following plowing when the ground is moist. Fertilizers are not used to any great extent.

Table 3 gives the mechanical analyses of samples of the surface soil, subsurface soil, and subsoil of Laveen clay loam.

TABLE 3.—*Mechanical analyses of Laveen clay loam*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
510859	Surface soil, 0 to 7 inches	0.1	0.6	0.6	12.0	29.8	37.2	19.5
510860	Subsurface soil, 7 to 38 inches	.1	.6	.8	16.3	29.2	32.7	20.6
510861	Subsoil, 38 to 62 inches	.6	.8	.6	10.9	21.4	39.7	26.0

TOLLESON LOAM

The surface soil of Tolleson loam to a depth ranging from a few inches to 2 feet is mildly calcareous pale yellowish-brown loam having a faint reddish tinge. This layer is underlain by a layer of light-brown or reddish-brown moderately calcareous compact silty

clay loam or clay which continues to an average depth of about 40 inches, where it grades into grayish-brown very compact silty clay or clay highly mottled with lime and containing a few lime-carbonate nodules. In moist fresh cuts this layer appears rich brown in color, with gray patches and flecks where the lime nodules and mottles occur. In most places it is high in soluble mineral salts. It commonly extends to a depth of 6 or more feet, but in a few places at a depth of 5 or more feet it is underlain by the parent material of slightly lighter texture and more friable consistence, in which fewer nodules occur. The materials are of mixed origin and are principally of water-laid accumulation.

Several tracts of this soil have been mapped near the lower boundary of the alluvial fans on the north side of Salt River in the southwest part of the surveyed area. The surface, where not leveled by irrigation, is marked by a few hummocks about 10 inches high of lighter-textured material. Most of the land slopes at the rate of about 20 feet to the mile. Surface drainage is good, but subsoil drainage is very slow. The water table must be kept at least 10 feet below the surface if high accumulations of alkali salts, which are now high over much of the soil, are to be avoided. Reclamation by leaching has been effected on part of the land, but this takes a long time as water passes slowly through the comparatively tight subsoil.

TOLLESON FINE SANDY LOAM

Tolleson fine sandy loam is similar in profile to Tolleson loam, but the textures of the various layers are correspondingly lighter. The subsurface layer is only slightly compact light loam, the subsoil is compact clay loam, and the deeper parent material is slightly compact loam. The soil material is of highly mixed origin.

This soil occurs on or near the lower extremities of the old alluvial-fan slopes where they merge with or break to the lower-lying soils. The subsoil appears to be water-laid, but much of the surface soil is wind modified or wind laid. The soil is mapped on the north side of Salt River in the southwestern part of the area and on the south side of the river about 2 miles northeast of Laveen. The surface soil material of the last-mentioned area is coarser than typical.

Tolleson fine sandy loam lies on gentle or moderate slopes on the breaks of the fans. The surface, where not leveled for irrigation, is slightly undulating with many hummocks from 1 to 2 or more feet in height. Drainage of the surface soil is good or excessive and of the subsoil is fair. The greater part of the subsoil has been subjected to a high water table and at present contains some soluble mineral salts. Much of the soil is at present affected by accumulations of alkali. Alfalfa and cotton are grown on cultivated areas. Alfalfa yields from 2 to 5 tons and cotton averages about two-thirds bale to the acre. This is a very easy soil to cultivate.

The results of mechanical analyses of samples of the surface soil and three layers of the subsoil of Tolleson fine sandy loam are shown in Table 4.

TABLE 4.—*Mechanical analyses of Tolleson fine sandy loam*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
510863	Surface soil, 0 to 20 inches	0.4	2.2	5.4	16.3	35.2	27.5	13.0
510864	Subsoil, 20 to 38 inches	.4	3.0	3.7	22.5	31.4	23.5	15.2
510865	Subsoil, 38 to 50 inches	.4	2.0	4.5	17.0	21.7	37.2	17.2
510866	Subsoil, 50 to 72 inches	.1	1.2	2.9	26.5	28.8	27.5	12.9

TOLLESON SILTY CLAY LOAM

The soil profile of Tolleson silty clay loam is essentially the same as that of Tolleson loam from which it differs only in surface texture.

This soil occurs in many bodies in the southwestern part of the area southeast and east of Cashion. It occupies comparatively low-lying nearly flat areas. The surface is generally smooth but there are a few low hummocks or irregularities. The soil is of heavy texture, compact consistence, and massive structure, and the pore space is too small to allow free drainage. Much of the lower-lying soil has a high water table and, as is shown on the alkali map, large areas are affected by high accumulations of alkali. Such areas are covered with a patchy growth of samphire, greasewood, jasmine, mesquite, and arrowweed. Areas in cultivation are utilized principally in the production of cotton and grain, and good yields of both are reported. The soil has a tendency to form resistant clods if not plowed and cultivated under proper moisture conditions.

Although the land drains very slowly it is possible, if the water table is kept below a depth of 10 feet, to reclaim it by leaching. From moderate to long periods of flooding would be necessary to wash the alkali from the soil.

SUNRISE CLAY LOAM

To a depth ranging from a few inches to 2 feet—rarely more—the surface layer of Sunrise clay loam consists of brown or chocolate-brown moderately calcareous clay loam material carrying a few lime-carbonate nodules. The fine material of this layer probably consists of comparatively recent sediments of mixed origin that have been deposited from turbid irrigation and flood waters. Beneath this darker surface soil is a light-brown or pale yellowish-brown moderately calcareous light clay loam subsurface layer which also carries a few lime-carbonate nodules. It extends to a depth ranging from 2 to 3½ feet, at which depth it is underlain by an upper subsoil layer of grayish-brown compact clay loam containing gray mottles and streaks of lime and many lime nodules. This layer grades at a depth ranging from 4 to 6 or more feet, into brownish-gray firmly cemented lime-carbonate hardpan of heavy clay loam or clay texture. This hardpan is probably the result of the existence, for a long-continued period of time, of a high water table which caused the heavy subsoil to become highly impregnated with the cementing minerals

deposited from solution. This hardpan can not be penetrated with the soil auger, and on drying, fragments become very hard. When it is moist minute openings allow the slow movement of moisture and the hardpan crumbles or can be cut when struck a moderately hard blow.

Included with mapped areas of this soil are a few small light-textured loam bodies which occur on low ridges. These lighter-textured areas are more numerous at the north boundary of the large area south of Tempe, where the surface soil is influenced by a continuation of the Mohave soils. Other included light-textured areas lie about a mile southwest of Tempe and near Bell Buttes.

The soil occurs in one large and several small areas south of Tempe in the low nearly flat area, where the old alluvial fans, sloping from the east and west, merge. The land is very smooth, and the average slope is about 7 feet to the mile. The heavy surface soil absorbs water slowly, and the compact subsoil and fragmental hardpan impede internal drainage. The underground water is being kept lowered by pumping. As is shown on the alkali map, much of the soil is at present strongly or moderately affected by accumulations of alkali. Under present conditions of water-table control it is believed no further extensive areas of alkali accumulation will develop.

SUNRISE SILTY CLAY

Sunrise silty clay is somewhat heavier in texture than the clay loam of the Sunrise series, but in other characteristics the profiles are very similar.

The largest area of this soil is about 2 miles south of Tempe. Other areas occur in that vicinity and farther south on low comparatively flat land. Drainage is naturally poor, but, owing to the comparatively small extent of such poorly drained lands in the area, the number of pumps necessary to keep the ground water low does not markedly increase the acre drainage cost. With the water table kept 10 feet below the surface, this soil drains slowly but effectively. The alkali map shows that accumulations of alkali occur in parts of this soil. At present the water table is nearly everywhere low.

A low-lying poorly drained area of soil that conforms closely to Sunrise silty clay has been included in mapping. The surface soil is mottled with gray and brown organic-matter stains. This soil occupies a low swale in the southwestern part of the area. Much of the land is covered with tules and swamp vegetation.

Grains, cotton, Bermuda grass, and some alfalfa are produced. Grains are reported to return very good yields and other crops to produce average yields.

PINAL GRAVELLY FINE SANDY LOAM

To a depth of about 10 inches the surface soil of Pinal gravelly fine sandy loam under virgin conditions is pale-red, faded reddish-brown, light-purplish, or pinkish-brown gritty fine sandy loam containing a large number of angular or rounded gravel. In some places the surface layer has been leached of free lime carbonate, but over most of the soil a number of lime-carbonate hardpan fragments are present. The surface soil is underlain by grayish-brown or light pinkish-gray soil material intermingled with numerous lime hard-

pan nodules and fragments. This layer is loosely cemented, leaving interestitial spaces into which soil from the surface has worked down. At an average depth of 20 inches the subsurface soil grades into gray lime-carbonate hardpan varying from moderately cemented fragmentary material to firmly cemented massive layers that extend to a depth of 6 or more feet. This hardpan ranges from almost pure lime carbonate to a cemented mass of gravelly or stony materials. The depth of the surface soil varies greatly, and in many places hardpan is exposed on the surface. The organic-matter content is exceptionally low.

A large area of this soil is mapped about the Papago Saguaro National Monument, on smooth-surfaced gently sloping alluvial fans. Rain water does not penetrate easily. Surface drainage is well developed, but in this region of light rainfall water does not penetrate the subsoil. The land is not utilized for agriculture but supports a growth principally of various cacti, creosote bush, and ironwood.

Pinal gravelly fine sandy loam, stony phase.—The stony phase of Pinal gravelly fine sandy loam is essentially the same as the typical soil, but most of it occurs higher on the fans or nearer the source of the soil-forming materials and contains a larger proportion of coarse gravel, together with many cobbles and stones. The land is not used for agricultural purposes but supports a growth of various cacti and creosote bush. It is very low in organic matter and water-holding capacity. Surface drainage is good, but subsoil drainage is almost entirely arrested and during periods of appreciable rainfall most of the water falling on the land is lost by run-off through shallow surface washes. This stony soil is mapped in and about the Papago Saguaro National Monument. A strip occupies the breaks of the old alluvial fan northeast, north, and west of Mesa; an area lies north of Phoenix along the Arizona Canal; and a patch occurs at the foot of Bell Buttes southwest of Tempe.

PINAL LOAM

The profile of Pinal loam resembles closely that of Pinal gravelly fine sandy loam, with the exception of a heavier texture in the surface soil.

This soil occurs in the vicinity of the Papago Saguaro National Monument, east and southeast of Scottsdale, northeast of Mesa, and on the breaks of the old alluvial fan north of Laveen, where it occurs as narrow strips associated with soils of greater agricultural value. It is utilized and cropped to cotton, alfalfa, and grains. Cotton yields about 300 pounds to the acre and alfalfa about 3½ tons. Grain produces fairly well where irrigation is given particular attention.

RIVER WASH

In the Salt River Valley area river wash occurs, in some places in areas nearly a mile wide, along the margins and in the channels of Salt, Gila, and Agua Fria Rivers. It consists of beds of rounded bowlders, cobbles, gravel, and sands of highly mixed origin. Areas are irregular or slightly undulating. At flood periods these areas are subject to overflow, and the soil materials are frequently shifted about and new channels are cut. Many rather irregular-shaped islands of Gila fine sand separate strips of river wash.

Willows, cottonwood trees, and arrowweeds grow in scattered clumps or patches on this land, the remainder of which is either barren of vegetation or is occupied by annual weeds. Owing to its coarse texture and low-lying flood-swept position river wash is utilized only for the small amount of grazing which it affords.

ROUGH BROKEN LAND

Rough broken land consists of parts of old alluvial fans which have been roughly dissected and eroded. The principal area is in and about the Papago Saguaro National Monument. Here the soil is similar in profile to greatly eroded soils of the Pinal series. In some places the surface is covered with angular and subangular rocks and gravel, and in others small gravel and hardpan fragments or massive lime-cemented hardpan predominate in the surface layer. Many arroyos, from 2 to 20 feet deep, have been cut down the slopes of the fans.

In this area rough broken land is covered by a variety of desert plants. The uneroded parts of the fans support a liberal growth of creosote bush, desert sage, various cacti, and desert shrubs and flowers, and along the arroyos, mesquite, ironwood, and paloverde trees are rather abundant.

Owing to unfavorable relief and position with regard to water for irrigation rough broken land is of little agricultural importance and is utilized only for the slight grazing it affords, though small areas in the Papago Saguaro National Monument could be used for crop production if irrigation water were provided.

ROUGH STONY LAND

Rough stony land includes the rough-surfaced rocky hills or buttes of the area. These areas are almost barren of soil material and vegetation and support only a scattered growth of various cacti and other desert plants. They are important in their relation to the soils of the area only as sources of soil materials. The rock materials are varied, consisting of granites, metamorphosed granite, andesite, lava, mixed breccia, sandstones, and metamorphosed sandstone.

Rough stony land is inextensive, the largest area forming part of Camelsback Mountain and several occurring north of Tempe, in and about the Papago Saguaro National Monument, and one area including Belle Buttes southwest of Tempe.

AGRICULTURE

The date of the beginning of irrigation and tillage of the soils in Salt River Valley is unknown. Indian tribes, known as the prehistoric canal builders, constructed brush-and-rock dams in Salt River and diverted the waters through hand-constructed canals to various parts of the valley. By a rather crude system of irrigation they raised such crops as corn, beans, squash, melons, and millet or such grasses as provided edible seeds. The number of years the valley was inhabited or the amount of water diverted to these lands can not be accurately estimated, but judging from the extent of the canal work and the ruins of ancient villages, it would seem that it

must have been many hundred years. White people first began irrigation and agriculture in the Salt River Valley soon after the close of the Civil War, when military occupation was resumed. As the military forces offered protection to the farmers and remuneration for produce, settlers entered from the military post at Prescott and began to till what seemed to be the most favorable land. A few cattle were grazed, and hay and grain were produced and sold at Fort McDowell, a military camp a short distance northeast of the valley. The mining camps also provided a market for produce during this period. Dams and canals were soon built and water rights claimed by farmers' cooperative organizations which raised funds and promoted the work. In 1872, 7,000 acres of land were under cultivation on the north side of Salt River.

Crops suffered greatly during droughts when no water flowed in the river, and much trouble was experienced by the washing out of the dams and canals when floods occurred. The farmers realized the necessity for the storage and control of flood waters, and at their request surveys for dam sites were made. Following the enactment of the United States reclamation act, providing that funds from the sale of public lands in certain western commonwealths be used for reclamation development, the Secretary of the Interior in 1903 authorized construction of the Salt River irrigation project and set aside funds for the purpose. Following the completion of the Roosevelt Dam in 1911, a more permanent water supply was assured and agricultural development in the valley was greatly accelerated. Improvement and reclamation development of new lands have constantly taken place until to date more than 240,000 acres are in cultivation under the present project which is now owned and operated by the Salt River Valley Water Users' Association. A large proportion of the lands of the area covered in this survey are intensively farmed.

This is a region of highly developed commercial agriculture where the greater part of the crops is sold for cash. The principal cash crops are cotton, wheat, citrus fruits, cantaloupes, lettuce, table grapes, dates, strawberries, and watermelons. Less important cash crops sold principally on local markets are peas, tomatoes, onions, sweetpotatoes, potatoes, string beans, chili peppers, sweet corn, turnips, spinach, asparagus, pumpkins, squash, peanuts, carrots, and other garden truck. Among the tree crops grown to smaller extent but sold for cash are apricots, plums, peaches, figs, pomegranates, and pecans. Part of the alfalfa, a widely grown crop, is sold for cash and the rest is used on the farm, chiefly as feed for dairy cattle and work animals. Bermuda grass is grown for pasturage and for seed which is sold for cash. Crops grown principally for consumption on the farm are oats, barley, sorghums, corn, and Sudan grass.

Cotton occupies the largest acreage in the area and is grown on practically every type of soil. The medium or light textured soils give the most satisfactory returns. Both long and short staple varieties are grown, but the short-staple or upland varieties predominate. In the season of 1924–25, data gathered on the Salt River irrigation project show 53,244 acres of short-staple and 30,536 acres

of long-staple cotton. Pima is the principal long-staple variety and Mebane, Acala, and Lone Star are the main short-staple varieties. The cotton is ginned and baled locally and a part of it is marketed through cotton growers' associations.

Two diseases destructive to cotton have appeared in this area. Root rot, a fungous disease, affects the taproot of the plant and lives through the winter in the soil. The practice recommended for its control is to grow such crops as cereals, corn, and sorghum, which have no taproot. Black arm, or bacterial blight, has been injurious to Pima cotton and to less extent to the short-staple varieties. This is a bacterial disease that attacks the plant in all stages of growth. The bacteria are carried over on the seed. Treatment of the seed with sulphuric acid will control this disease.[4]

Alfalfa is the crop second in importance. The 1920 census shows 66,071 acres in Maricopa County planted to alfalfa in 1919, when the average yield was about 3 tons to the acre. Alfalfa is grown on all the well-drained soils. The principal varieties are Hairy Peruvian, Smooth Peruvian, and Chilean. Most of the hay is baled and stored and either sold locally for feed for dairy cattle and for winter feed for cattle and sheep or is shipped to outside markets in both the East and West. The second crop is sometimes cut for seed.

Root rot and crown gall, another fungous disease, slightly affect the alfalfa grown in the valley. The green alfalfa hopper, the grasshopper, and the harvester ant are also enemies of the crop. Probably the worst enemy, however, is the yellow butterfly, the larvae of which feed on the leaves. The chalcis fly does most damage to the alfalfa seed.

Citrus-fruit production has developed rapidly in recent years and is being greatly expanded at present. It is carried on in the more frost-free belts found on the higher slopes north and northeast of Phoenix, on the higher fans encircling Salt River Mountains, near the edge or breaks of the higher mesas north, northwest, and northeast of Mesa, and in the bottoms along Salt River northeast of Mesa. Frost protection by artificial heating is not practiced. The groves, with the exception of those on the bench lands near Mesa, where some of the orchard soil is clay loam, are all planted on loam or lighter-textured soils. Citrus thrips do some damage to the trees and fruit. These pests may be controlled by spraying the trees with lime-sulphur solution.

Arizona grapefruit ranks with Florida grapefruit on the markets, and the demand for it is increasing. In 1919, 18,311 grapefruit trees with a production of 27,987 boxes of fruit were reported in Maricopa County, and nearly all these are in the Salt River Valley. Many groves of young trees have been planted recently. The Marsh (Marsh Seedless) is the most popular variety. Other varieties are known as Duncan and Clayson. Most of the grapefruit are shipped to western markets.

In 1919 the 46,600 bearing orange trees in the county produced 79,596 boxes of fruit. The principal varieties of oranges are the Washington Navel, the Valencia, and several varieties of sweet

[4] Information regarding methods of treatment of these diseases may be obtained through inquiry from the University of Arizona, Tucson, Ariz.

seedlings grouped under the name Jaffa. The Washington Navel is the most important variety, and a thrifty mature tree will produce about 4 boxes a year. The Valencia yields more heavily than the Washington Navel. The Jaffa produce a heavier yield than either the Washington Navel or Valencia, but usually return lower net profits. Most of the oranges are sold on eastern markets.

A few lemons are produced in the area. They are principally of the Eureka variety, but a few of the Lisbon variety are grown. A mature tree yields from 5 to 6 boxes of fruit.

Only in recent years have the farmers turned greatly to the raising of truck crops at the expense of cotton and grains. Nearly all the truck-planted area in Maricopa County is within the Salt River irrigation project. Figures gathered and compiled at the project office for 1924–25 show the cantaloupe acreage to be 5,624 and the acre yield to be 225 crates. A large additional acreage has been planted in the valley during the present season (1926). The principal varieties are Heart of Gold, Pollock 10–25, and Honeydew. Cantaloupes are usually grown on loam or heavier-textured soils, either old alluvial or recent alluvial. The best results are obtained on the recent-alluvial soils. The melons are graded and packed in small sheds in the field and hauled in crates to a central shed, where they are loaded into cars. They are marketed principally in eastern and northeastern markets. In some seasons aphids are destructive to the cantaloupe crop.

Lettuce and other truck crops do best on the young soils of medium or heavy texture or on the more mature soils having a heavy-textured surface soil due to silting. Both spring and fall crops of lettuce are produced. In the Salt River irrigation project in 1924–25 there were 2,080 acres of lettuce planted, and the yield averaged 230 crates to the acre. Lettuce is essentially a cash crop. Owing to competition of other lettuce-growing districts, the price received varies greatly both during the season and in different seasons. The principal variety grown is the Los Angeles, also known as the New York Special and the Denver Market. Some commercial fertilizers are used in the production of this crop. Slime, a disease which affects lettuce, is caused chiefly by a fungus (Botrytis). The lettuce is shipped mainly to eastern and northeastern markets.

Wheat is produced in almost all parts of the area and has been grown largely on some of the lower lands where the water table was too high for the production of good alfalfa and other deep-rooting plants. The best yields are obtained on the well-drained medium-textured darker-colored soils. In the Salt River irrigation project the 16,812 acres of wheat reported in 1924–25 yielded an average of 18 bushels to the acre. Early Baart is the variety most commonly grown, and a little Sonora and Marquis are produced. When cut for hay wheat yields about 1½ tons to the acre and when harvested for grain yields range from 15 to 50 bushels to the acre, depending on the soil, farming methods practiced, and the season. Most of the seed sown is treated to prevent smut.

The sorghums are highly important crops in the valley. The Maricopa County census for 1920 reports an acreage of 17,427 acres in grain sorghums with a production of 514,415 bushels in 1919. Nearly all the sorghums raised in the valley are of the grain-

producing varieties. The dwarf variety of milo, which is an important crop, is preferred for this section. Several strains of this variety, Standard, Avondale, and Double Dwarf, are produced. About 1½ tons of grain to the acre are obtained. Hegari yields equally as well as milo. It is a good grain and silage crop and makes a hardy, vigorous plant particularly well suited to the irrigation conditions of the valley. The average yields of grain are a little less than of milo, but because of its silage and fodder value and the fact that the heads are produced on straight stalks, thus making harvesting economical, this is becoming the most popular grain sorghum crop in the valley. Feterita, another grain sorghum, was widely produced but has recently been almost entirely replaced by hegari. Its fodder value is superior to that of milo but the grain yield is smaller.

Of the sorgos (sweet sorghums), Gooseneck, Honey (Honey Drip), and Sumac (Red Top) are the principal varieties grown. However, none of these is grown extensively. The Gooseneck is a very rank-growing variety produced both for silage and sirup. It yields a larger quantity of sirup than other varieties grown in the valley. The Honey variety makes a tall, leafy, and somewhat coarse plant, the stalks of which are sweet and juicy and valuable for sirup. It yields heavily but as the stalks grow from 8 to 9 feet high they lodge very badly, causing much loss. Sumac is probably the best sorgo grown for silage purposes in the valley. It has straight erect heads, and grows to a height of 7 or 8 feet, rendering it easy to harvest with a corn binder. It requires about 120 days to mature and yields from 12 to 20 tons of silage to the acre. The sirup produced is usually of good quality.

The medium-textured or fine-textured soils are the best for sorghum crops. Three diseases—kernel smut, head smut, and sorghum blight—affect sorghums in the valley. Kernel smut affects the sorgos but not milo under ordinary conditions. Hegari and feterita are somewhat resistant to this disease, which can be controlled by treatment of the seed with formaldehyde solution. Head smut affects the entire head. It is carried over from season to season by spores in the soil and in the seed. Clean seed and crop rotation are the best methods of control. Sorghum blight, a bacterial disease, has not affected the plants seriously in the valley.

Sudan grass, a member of the sorghum family, is grown to a large extent. In 1925 within the Salt River irrigation project the 2,202 acres grown produced 4 tons to the acre. This grass is grown most extensively on the clay loam or heavier-textured soils. The yield is from 3 to 6 tons to the acre for the season. This is also one of the more important pasture grasses of the valley, and a part of the crop is utilized for seed production. Yields of seed range from 500 to 700 pounds to the acre.

Pastures of various grasses are very important in the agriculture of the Salt River Valley area and are one of the larger sources of cash income. Much of the grain, grain and alfalfa mixed, clovers (sour and bur), and Bermuda and other grasses is either pastured in late winter and early spring or used as permanent pastures. The report of the Salt River Valley Water Users' Association shows that in 1925, 21,273 acres of grain pasture were grazed principally by

livestock driven or shipped into the valley from outside points. This represents a return to the farmer of about $8 an acre. The report shows 31,712 acres in permanent pasture valued at $20 an acre.

Corn for silage is produced in conjunction with dairying. In 1925 the 3,973 acres of silage corn in the Salt River irrigation project yielded 9 tons to the acre. Mexican June is the principal variety grown for silage.

Barley of the 6-rowed and beardless varieties was grown on 5,461 acres of project lands in 1925, when the average yield was 1,700 pounds to the acre. This crop is grown on nearly all soils of the valley, but more extensively on the heavier-textured or more poorly drained soils or on soils containing small amounts of alkali.

Red Rustproof (Red Texas) oats are grown for hay to some extent. In 1925 the 2,224 acres seeded produced 1¾ tons to the acre. Oats are grown on a variety of soils but principally on the well-drained, alkali-free, heavy-textured soils.

In 1926 Bermuda grass occupied 1,540 acres of the Salt River irrigation project lands. This crop is adapted to land of such high alkali content and high water table as to be unsuited to most crops. This grass seeds itself and spreads rapidly. Yields range from 150 to 400 pounds of seed to the acre, with an average of about 200 pounds. The seed is shipped, principally to the Southern States, for lawn and pasture grasses. Bermuda grass is considered a pest in the valley when it is allowed to spread among other crops.

Table-grape production is important in the valley at present and is being rapidly increased by new plantings. Sultanina (Thompson Seedless) is the leading variety grown, and Malaga ranks second. Small plantings of other varieties, some of which are in the experimental stage, are grown. On the Salt River irrigation project there were 902 acres of grapes in 1925, the yield averaging about 12 tons to the acre. Most of the vineyards are planted in or near the citrus belt, but others are widely distributed over the valley. The grapes on light sandy soils in the citrus belt not only ripen earlier but are of better quality and of higher sugar content than those planted elsewhere. One of the worst pests of grapes is the leaf hopper, an insect that sucks the sap from the leaves and vines. A nicotine-sulphate spray is used to control this pest. Other pests are the flea beetle, which eats the vines when they are young and succulent, and a June-bug beetle that eats the fruit. The flea beetle is controlled by spraying. The powdery mildew, a fungous disease, affects some of the grapes. Sulphur dusting and spraying are practiced to control this disease.

Date culture promises to be of some importance in the Salt River Valley. At present (1926) about 80 acres are planted to dates. The increase of commercial plantings is slow, owing to the scarcity of offshoots of high-quality varieties. The development of varieties is slow, as much time is needed to test each variety for adaptability, production, and quality. The most promising varieties now being planted are the Makoom, Khalasa, Iteema, Hayany, Khadrawy, Kustawi, Halawy, Zehedy, and Deglet Noor.

Strawberries are probably the most important small fruit. The Klondike, Arizona Everbearing, and Michel Early are the most popular varieties. The berries ripen in April and May, when a good price is usually received on local markets.

Watermelons are produced on rather large acreages. In 1923, there were 786 acres planted on Salt River irrigation project lands. These yielded 7½ tons to the acre. Kleckley Sweets and Irish Grey are the leading varieties produced.

Peas are grown largely for commercial purposes and shipped green to eastern markets. The Stratagem, Lexatonia, and Yorkshire Hero, fall varieties, and the Dwarf Telephone, a spring variety, are produced.

Tomatoes are planted in the seed bed about the first of February and transplanted in the field between April 1 and July 1 or are planted directly in the field under nightcaps. Improved Stone and Earliana are the principal varieties grown. Onions are planted in the seed bed between the middle of September and the middle of October and are placed in the field between December 1 and March 1. Crystal Wax, Bermuda, and Sweet Spanish are the varieties grown. Yields range from 10,000 to 30,000 pounds to the acre.

Figure 2 shows the distribution of various crops in selected representative sections of the Salt River Valley area.

Dairying is an important farming industry, most of the dairy products being marketed locally. The dairy cattle raised are Holsteins, Jerseys, Guernseys, and a few Ayrshires. The dairies are located in all parts of the area except the citrus belt. Dairy products in Maricopa County in 1919 were valued at $1,754,611. A few milk goats are kept.

The beef-cattle and sheep-raising industries are centered in the higher parts of the State, and during the cold winter months the animals are moved south to the low desert areas around the cultivated valleys. During years when feed is insufficient in the desert many animals are driven or shipped into the valley where they are pastured. Many are brought in each year to be fattened for market. The Hereford is the principal breed of beef cattle and the Rambouillet is the favorite breed of sheep. The warm winter allows lambing in November and December, and the lambs are ready for market in April and May, when they are shipped to Kansas City and Los Angeles. Only a few hogs are raised. The value of animals sold and slaughtered in Maricopa County in 1919 was estimated to be $3,265,125.

Poultry raising is popular, and poultry farms are distributed throughout the area. The principal breed of chickens is White Leghorn, but Rhode Island Red is a favorite among the farm and backyard poultry keepers. The value of poultry and eggs in Maricopa County in 1919 was $709,419.

Bee-keeping, for the production of honey and the sale of bees, is another important agricultural enterprise. Apiaries are scattered throughout the area. The blossoms of desert plants, citrus fruits, and other flowering plants provide materials for honey manufacture. Swarms of bees are raised and shipped to northern States where climatic conditions are not so favorable for bee production.

Methods of preparation of the land for certain crops, programs for the care of the crop, and systems of harvesting, handling, and marketing are of vital importance. Special machines, irrigation systems, and selected appliances for specific crops are also important in the planting and growing of various crops. The farm machinery

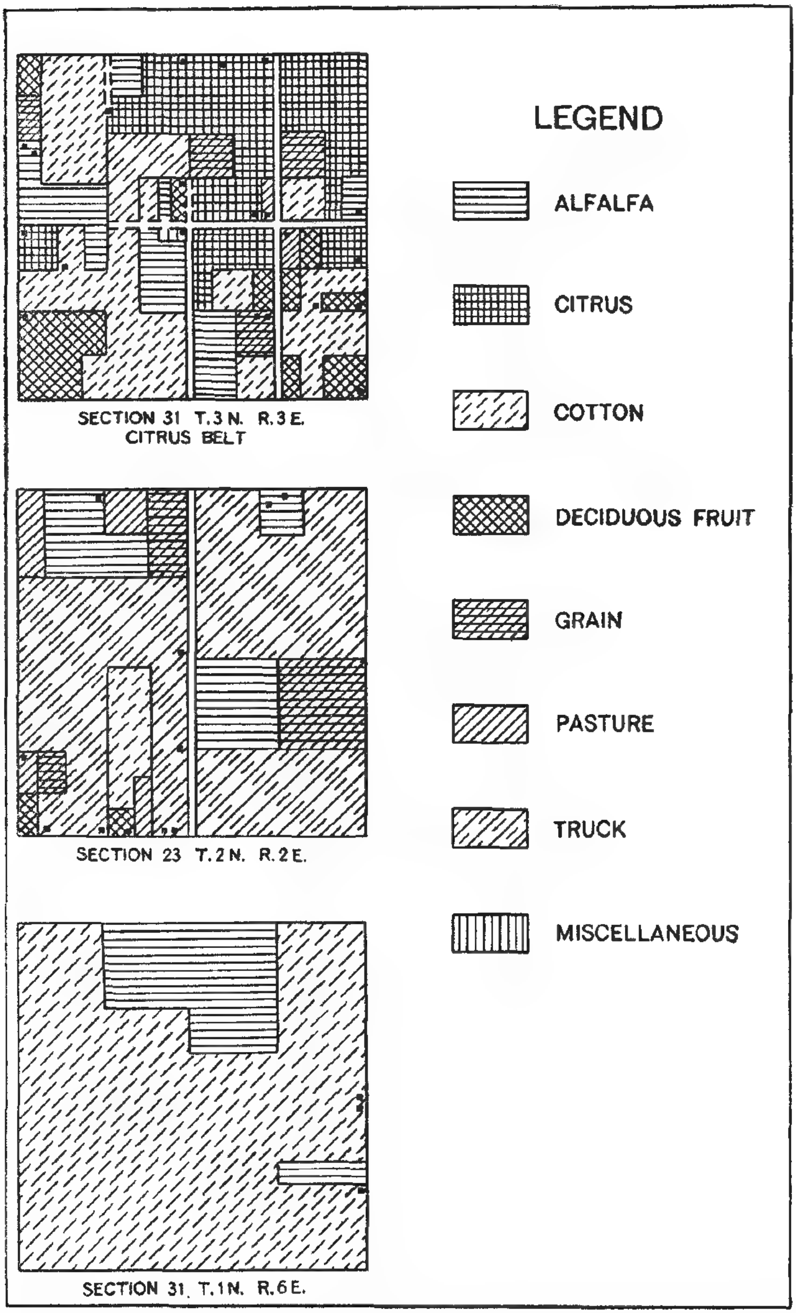


FIGURE 2.—Sketch map showing distribution of various crops in selected representative sections of the Salt River Valley area, Ariz.

varies with the crops grown. About 25 per cent of the cultivation is done at present (1926) with tractors, and about 75 per cent is done with horses and mules. The crop and stock report on the Salt River irrigation project taken in the spring of 1924 reports 749 tractors, 8,916 horses, and 3,549 mules in the area. The number of tractors has increased greatly since that date. Produce from the farm is hauled largely with auto trucks and trailers.

Commercial fertilizers, chiefly ammonium sulphate and sodium nitrate, are used on about 3 per cent of the cultivated land of the area. Some fertilizer is used in the growing of citrus fruits and a small amount on some of the truck crops. An increasing number of farmers practice plowing under green-manure crops. No systems of crop rotation are generally practiced. The farmer tries to crop the land as heavily and as often as possible, and as soon as one crop is taken off the land is prepared for or is planted to another. A few farmers have begun growing a few crops in rotation with a legume.

The size of farms ranges from 5 acres to as much as 640 acres, depending principally on the utilization of the land. The average size of farms on the Salt River irrigation project is approximately 40 acres at present (1926).

The 1920 farm census shows that 71.2 per cent of the farms of Maricopa County were operated by owners, 25.7 per cent by tenants, and 3.1 per cent by managers. A cash rent between $15 and $35 an acre, depending on location, productivity, and condition of the land, is received for rented lands, which are generally used in the production of annual crops.

In the Salt River Valley area, the character of the soil is secondary in importance to location as regards freedom from frost, desirability for home sites, and nearness to Phoenix or other towns, in determining the sale value of the land. However, other things being equal, there is a distinct relation between land values and soil types. Pinal gravelly fine sandy loam and its stony phase are recognized as being of little agricultural value. The alkali-affected areas are of little value and the poorly drained phases of the Gila series have very low value. Gila fine sand, because of its excessive leachiness, has a very low value and if sold alone would probably command not more than $10 or $20 an acre. The well-drained medium or light textured soils of the area are considered valuable for agricultural purposes, and in the truck, cotton, and general-farming districts they sell at prices ranging from $125 to $300 an acre, depending on improvements, location, and condition of the land. Water rights and cost of water are of material importance and influence the price of land.

In the citrus belt land that elsewhere sells at $200 an acre commands from $500 to $700. If the land is developed and producing crops of citrus fruits, grapes, nuts, dates, or other permanent crops the price is correspondingly higher. Land in grapes commands about $500 an acre, in bearing grapefruit orchards from $1,000 to $3,000, and in bearing date orchards from $6,000 to $10,000 or more.

None of the soils of the area contain an exceptionally high proportion of organic matter, and in many of them the proportion is very low. Those soils having a fair organic-matter content at

present are the medium and heavy textured soils of the Cajon series, the heavy-textured soils of the Gila series, and soils of the McClellan and other series which have been formed of material silting from irrigation waters. All other soils need crop management or some effective program which will increase the content of organic matter. Much of the land has been utilized for the production of cotton year after year. Rotations that include the growing of a legume crop on the land at least one-third of the time are recommended. Plowing under green-manure crops is effective if such a rotation can not be economically followed. Alfalfa or sour clover are good green-manure crops for this district. Tepary beans provide a good summer cover crop and a good green crop to be plowed under. Usually cotton stalks, which are occasionally burned in preparation for other crops, if cut fine and plowed into the soil will not interfere with later cultivation but will help maintain the organic-matter and water-holding capacity of the soil.

Recommendations regarding alkali reclamation and control are discussed in the chapters on alkali and drainage, and recommendations regarding irrigation practices are discussed in the chapter on irrigation and power development. In connection with crop production, however, it is advised that the irrigator study the character of his soil from the surface to a depth of 10 feet and, by means of the soil auger, watch the penetration of irrigation water. The penetration in various parts of the field is governed by the method of applying water, the slope of the land, and the distance the irrigation water is run over the field. Careful leveling in preparation for irrigation is recognized as highly important in irrigation farming.

A few spots, occasionally referred to as slick spots, occurring in the medium-textured soils of the Cajon series and in upland fan soils of medium or light texture are merely spots of silty soil. Irrigation water held on the surface long enough for the desired penetration in the predominating soil does not penetrate these silty spots, which consequently are barren. If these spots were irrigated while in a rough or plowed condition, and the water held on them until good penetration was effected, crops could be produced. After alfalfa or a similar deep-rooted crop is grown on such soil it takes water freely. The incorporation of straw or vegetable matter, which would tend to open the structure of the soil, would also be effective.

SOILS

The Salt River Valley area lies in the arid southwest soil region where the soil materials have been accumulated and weathered under arid desert conditions. The so-called valley occupies part of a broad plain that has been built up from water-deposited soil-forming materials and rock débris. Wells drilled in the valley show this material to be more than 1,300 feet deep.[5] A number of protruding rugged buttes or mountain summits in or bordering the valley have been partly buried by the valley-filling materials. In close proximity to or within a few miles of the borders of the plain, rough

[5] LEE, W. T. UNDERGROUND WATERS OF SALT RIVER VALLEY, ARIZONA. U. S. Geol. Survey Water Supply Paper 136, p. 133. 1905.

precipitous mountains rise to elevations from a few hundred to as much as 5,000 feet above the valley floor. The valley-filling material for the most part has been carried into the valley from the surrounding mountain districts by intermittent stream waters. The rock materials in these mountains vary widely in character. Fine-grained, coarse-grained, and metamorphosed granites, including geniss and schist; sandstones, breccias, and metamorphosed sedimentary rocks; and various lava rocks, including basalt, andesite, rhyolite, volcanic glass, and white tuff, are present. The streams carrying the soil materials have varied greatly in velocity, course, and duration of flow, with the result that a rather erratic sorting of materials has taken place. Large water-rounded bowlders, angular fragments, sand, silt, and clay occur in layers and lenses that vary in extent and change rapidly both horizontally and vertically.[6]

Cemented layers of lime carbonate, with which may be associated small amounts of magnesium carbonate, calcium and aluminum silicates, and iron oxides are other materials which have been developed in the older valley fill. These layers have probably been formed by deposition of the mineral materials from solution and are often spoken of as "caliche," which term is used locally to refer to lime concentrations in various forms and degrees. The materials are rendered soluble by chemical and weathering reactions and are dissolved and carried by percolating waters from the disintegrating rock and soil particles and deposited at the depth of water penetration, forming a hard calcareous layer. The degree of leaching and weathering, the amount of lime accumulation, and the amount and nature of the accompanying soil and rock in the cemented mass determine the thickness and degree of hardness of the layers. These lime-carbonate hardpan or fragmental hardpan layers vary in depth of occurrence, in thickness, and in degree of accumulation and cementation of material. Each of the layers is probably correlative with a previous level of the valley floor.

In the younger and less maturely weathered materials of the valley fill, with which most of the soils of the survey are identified, the lime carbonate or caliche accumulations are represented by intermittently or softly cemented layers or by irregular lime-carbonate nodules or gray mottles of lime accumulation. (Pl. 1.)

Investigations in this survey deal more particularly with the present surface soil and the soil materials to a depth ranging from 6 to 10 feet. The weathered soils formed from the alluvial sediments are characterized by the development of compact subsoils in which there is generally an accumulation of the finer clay and colloidal materials. Such an accumulation materially affects the permeability, capillarity, and water-holding capacity of the soils, and the amount of and the readiness with which moisture is rendered available to growing plants. The depth, thickness, and comparative compactness or density of the layers is determined by age or degree of weathering, conditions of drainage and leaching under which the materials have accumulated and weathered, and character of parent material. In virgin areas the more maturely weathered soils are leached of lime to a depth of a few inches. Below this depth

[6] See footnote 5, p. 41.

the soil material is distinctly calcareous, the lime usually increasing in the subsoil materials which are generally mottled with gray flecks and accumulations of lime carbonate and which in many places become highly impregnated with it. A mass of lime-carbonate nodules or cemented hardpan layers occur in many places. In these soils the profile is essentially one that is acquired through weathering in place of the parent materials. (Pl. 1.)

The normally developed soil of this area is typically illustrated in the sandy loam member of the Mohave series. The 4-inch surface layer of this soil, in the virgin condition, consists of reddish-brown or brownish-red noncalcareous gritty sandy loam. This is underlain to an average depth of 18 inches by a slightly calcareous layer similar in texture but slightly redder in color. These two layers are commonly friable and pulverulent or without any noticeable structure, but in a few places the structure is slightly granular. The next lower material, comprising the upper subsoil layer, consists of highly calcareous very slightly compact but friable sandy loam mottled with accumulations of lime carbonate and a few iron stains. This material is pinkish when finely crushed, but fresh fractures show gray lime and reddish iron mottles. This layer continues to an average depth of 28 inches and grades into pinkish-gray or gray weakly cemented very highly calcareous loam which breaks into irregular-shaped chunks with many small irregular-shaped lime-cemented fragments or nodules. On wetting, the weakly cemented material is easily pulverized to a loose friable mass. At a depth of 4½ or 5 feet the subsoil grades into brown highly calcareous rather friable gritty sandy loam parent material.

This soil carries considerable gritty coarse and fine sand particles throughout. The profile is typical of a long-aged soil which has resulted from weathering, under arid southwestern desert conditions, of materials that have been transported by water and deposited to form a very well-drained alluvial fan. In some areas the material is derived entirely or mainly from granitic rocks, but in many others it is derived from rocks of highly mixed origin. Some of the material has been transported less than a mile, whereas some has been carried from 20 to 50 miles. Particles carried only a short distance are decidedly more angular and sharp edged than the more or less rounded rock fragments of material transported for greater distances.

The weathering agencies responsible for the formation of this soil are long hot summers and short moderate winters, which are conducive to rapid or large annual oxidation and chemical reaction, and an average rainfall of 9 inches, which is sufficient to leach the lime from the topsoil to a depth of a few inches and the clay and easily moved material to a depth of 18 inches. Where soils are neutral or alkaline in reaction, as they are in this soil region, the finer clay has probably been dispersed by the presence of sodium. Such deflocculation of the soil aggregates has made the translocation of the fine particles possible. These materials have been deposited at the depth of water penetration or where the soluble material has accumulated. Such eluviation of the surface layers and illuviation in the subsoil layers are responsible for the lighter-textured friable surface soils and heavier-textured compact and granular or some-

what cemented subsoils. Most of the Mohave soils, of which the sandy loam type is representative, were in the earlier survey in the Salt River Valley included with a broad and somewhat heterogeneous group of soils designated as the Maricopa series.

All the well-drained upland alluvial fans of this area have been subjected to similar processes of weathering, and the many differences in amount of leaching of the surface soil and the amount of accumulation or cementation in the subsoil are indicative of the degree of weathering. The lime accumulation is, in some of the slightly weathered soils, revealed only by effervescence with dilute hydrochloric acid, whereas in the more mature Mohave soils it is visible as flecks and mottles and in many places in the form of small irregular-shaped but somewhat spherical concretions from 1 to 4 millimeters in diameter. In the still more mature soils the lime-carbonate nodules are more abundant in the subsoil or a firm cementation, which is effected principally by lime carbonate, occurs. This cemented layer, though very high in lime carbonate, probably carries small amounts of magnesium carbonate, calcium and aluminum silicate, iron oxides, and other minerals that have been accumulated under existing weathering conditions.

The relation of the soil to agricultural practices and potential productivity is dependent on or is markedly influenced by the degree of development brought about by weathering agencies. The characteristics of the subsoil, indicating the degree of maturity of the various soils, have been of major consideration in the differentiation of the various soil series of this area.

Soils similar in development and profile to the Mohave soils are grouped in the McClellan, Laveen, Pinal, and Sunrise series.

Soils of the McClellan series have been differentiated from those of the Mohave because of their darker-colored surface layer of higher organic-matter content. These soils occur on old alluvial fans where deposition has occurred both naturally from surface flood waters of the alluvial fans and artificially from muddy irrigation waters. Below this darker surface deposit the soil profile conforms to that of the Mohave soils except that some lime carbonate occurs throughout. This more uniform distribution of lime is caused by deposition of lime from percolating and rising soil waters. These soils were mainly included under the broad group of Maricopa soils in the earlier survey. Some of the heavier-textured materials were included with Salt River adobe.

The Laveen series includes soils related to the Mohave in degree of weathering and formation. The amount of accumulated lime in their profiles indicates greater maturity. The presence of much lime and a number of lime-carbonate concretions or nodules in the surface soil is a characteristic which is not normal or typical of profile development under existing weather conditions. The topographic position of the soils suggests the probability of erosion of the original surface soil leaving the lime-impregnated subsurface exposed. Seepage of lime-impregnated water to the surface where evaporation has taken place probably has supplemented the accumulation of lime in the surface soil where a number of lime concretions or nodules varying from very minute to an inch or more in diameter have been formed. The accumulation of iron or clay in the surface

soil is not noticeable, but lime carbonate has accumulated until a nodular layer or fragmental hardpan has been formed. This hardpan layer is hard when dry. When bored into with the soil auger it resists penetration but breaks apart irregularly. It may be broken into many small fragments when struck with a soil hammer. When wet or under irrigation the material softens and allows water to pass through slowly. Plant roots also make an entrance through the openings. Most of the Laveen soils were included with the Maricopa soils in the survey of 1900.

Soils of the Tolleson series are very similar to those of the Mohave but have been differentiated because of apparent modification caused by physical and chemical reaction of accumulated alkali salts. The surface soils and subsoils are of a somewhat paler-yellowish tint. In most places the surface soil is rather mildly calcareous, and the typical subsoils have compact and somewhat impervious layers and contain accumulations of salts. In many places the surface soils also contain accumulations of alkali and in areas of excessive salt accumulation may be characterized by a well-developed surface alkali crust which is in some places underlain by a thin layer of finely granular flocculated mulchlike material. However, large areas of these soils have been leached of excessive salts and are utilized for agriculture.

Soils of the Pinal series are very similar to those of the Mohave series in horizon development. The degree of weathering, however, is much more mature than in the Mohave soils. The subsoil contains an accumulation of lime that has formed a firmly cemented hardpan that is very nearly or completely impervious to soil moisture and plant roots. These soils were included with the Maricopa soils in the early survey.

The Sunrise soils, as mapped in this area, somewhat resemble the Mohave but appear to have developed under conditions of restricted drainage. The surface soil has been altered by the deposition of silt from irrigation water. The surface soil is dark colored and very similar to that of the McClellan soils but resembles that of the Laveen soils in that it contains many lime concretions. These may have been present in the exposed surface soils previous to the silting. The subsoil, which approaches a fragmental hardpan, has been developed much as has that of the Mohave soils, but probably the deposition and accumulation have been supplemented by accumulation of lime carbonate from solution in carbonate-impregnated subsoil waters which have approached the surface. In many places the cemented horizon extends to a depth of 15 or more feet. A number of softer layers appear within the altered horizon in places where smaller amounts of lime carbonate have been deposited and where the original soil structure is easily discernible. These soils were mainly included with Maricopa loam in the earlier survey.

The recently deposited soils of the area, or those that have had very little profile development owing to leaching and weathering processes, are nearly all of alluvial origin. Only small areas of wind-laid or wind-modified soils exist. These have been grouped in various series of alluvial soils.

The Cajon and Gila series include the recent and young soils of the area surveyed.

Soils of the Cajon series are composed of dull-brown or light-brown highly micaceous materials of mixed origin. A 6-foot exposure shows a uniform recent profile of friable mellow even-structured material without consistent lime accumulation or development of compact horizons. The lighter-textured soils of the series are commonly slightly stratified, and the heavier members are almost free of stratification. The subsoils are generally of slightly lighter texture than the surface soils. These soils are mildly calcareous throughout. The soil materials have been transported by streams and deposited along stream courses or laid down over broad valley surfaces. The materials are derived from rocks of mixed character but contain large amounts of mica. Most of the soils of the Cajon series were recognized in the earlier survey under the name of Glendale loess.

The Gila series represents a group of recent stream-deposited soils. The surface soils and subsoils are uniformly light brown or rich brown in color in the light-textured soils and dark brown or dark chocolate brown in the heavy-textured soils. In almost all places the subsoils are lighter textured than the surface soils and in many areas leachy coarse sandy and gravelly materials are present in the lower part of the subsoils. The soil materials, which had their origin in a variety of rocks, have been transported long distances and deposited in most places from comparatively fast-flowing water. In all the light-textured soils the color is uniform to a depth of 6 or more feet, but in the heavy-textured soils the surface soil to a depth ranging from a few inches to 3 or more feet is dark chocolate brown and the underlying material is similar to that of the lighter-textured soils. Both surface soil and subsoil are mildly calcareous. No characteristic structure horizons have developed, but a slight stratification caused by wind deposition is noticeable in the surface soil material of Gila fine sand, and in the layer of material deposited from irrigation water in the heavy-textured soils a division of material has been effected. The finer particles, together with part of the organic matter, have been removed to a depth ranging from 6 to 10 inches below the surface and have accumulated just below that depth, causing a slight compaction of the material. This translocation of materials has occurred very recently as compared with the usual modification in profile caused by natural weathering and leaching and is believed to have been accelerated by tillage and downward movement of irrigation water. Areas have been subjected to high-water table conditions which have caused an accumulation of soluble salts. If by adequate drainage the water table is kept as much as 8 feet below the surface, the alkali areas may be easily leached and rid of harmful salts by a system of flooding. The soils of this series were mainly included with the Pecos and the Salt River soils in the survey of 1900.

In connection with the study of the soil profile and other soil characteristics the character of the predominating native vegetation has been observed. Many of the plant groups not having extremely wide adaptations are closely indicative of certain soil characteristics. Although most of the Salt River Valley area has been cleared of its native cover a few areas of virgin desert exist, and the vegetation

along uncleared fence rows has afforded information about soils and plant adaptations.

The rugged or rocky hill or mountain areas support mainly a growth of the various cacti and paloverde. In many places the soils of the Pinal series are marked by a comparatively dense growth of giant and cholla cacti with which some paloverde, creosote bush, and various less prominent desert plants are usually associated. The comparatively high-lying fan soils of friable consistence and light texture are covered with a growth of creosote bush, which varies from rather sparse to dense and from 3 to 7 feet in height. The intermediate or comparatively low-lying light and medium textured alluvial-fan soils of low salt content support a moderate or dense growth of desert sage that stands about 20 inches high. In the area between the creosote bush and desert sage regions the vegetation becomes mixed, and the presence of bur sage is noticeable. In the low poorly drained areas of high salt content on either mature or young soils a scattered or dense growth of greasewood, seepweed, inkweed, and salt grass occurs. Ironwood is common along washes or in well-drained areas where it is associated with paloverde, various cacti, and wild marguerite. Mesquite grows on many soils under a wide range of salt accumulation conditions, but it is most prevalent in areas where the water table is within 20 feet of the surface. Jimmy weed has a very wide distribution, growing in desert areas and along irrigation ditches and fence rows throughout almost the entire area. Desert broom grows on a wide variety of soils but usually near canals or where moisture is available near the surface. The wild maguerite is found principally on the high well-drained desert lands. A growth of arrow weed is common along many of the canals but is pronounced along roadsides where much water is available in the subsoils. Along canals in areas of recent soils much of it grows to a height of 10 or more feet.

IRRIGATION AND POWER DEVELOPMENT

Irrigation was practiced in the Salt River Valley by prehistoric Indians. Approximately 150 miles of canals built by them have been traced in the valley. The Indians diverted the waters of the streams at flood periods, during which the rivers carried large quantities of silt, clay, and sand. The fine sediments of the muddy irrigation water were deposited on the surface of the irrigated lands. Modern irrigation in the valley was begun by the whites in 1867 in a manner very similar to that practiced by the Indians. The lands which were most favorably located with respect to diversion of water from streams were irrigated and cropped. In many places the sediments deposited are from 3 to 4 feet deep. Since the construction of controlling and storage dams farther up Salt River, the amount of silt deposited on the land from irrigation waters from this source is comparatively negligible. The flood waters from Verde River still carry an appreciably large amount of silt and clay.

The more recent developments, including the construction of the Roosevelt Dam on Salt River by the United States Reclamation Service and the later construction of additional dams and power

plants and irrigation and drainage works by the Salt River Valley Water Users' Association, are systematized to store and regulate the water. Results are highly efficient. Irrigation and hydroelectric power works of the Salt River irrigation project, including both completed works and those under construction, represent an investment of more than $23,000,000. The irrigation water supply is derived mainly from Salt and Verde Rivers but is supplemented by pumping from underground sources. Hydroelectric power is developed on Salt River and at points on the canal system in the valley.

The irrigable area of the Salt River irrigation project comprises 240,000 acres, and most of this area is in a high state of cultivation. The major project works include seven important dams, one of which is under construction, power-transmission lines and other appurtenances, more than 1,300 miles of canals and laterals, and 150 pumping plants for irrigation and drainage. The income from the sale of surplus power makes it possible to deliver water to the farmer at a very low charge. The farmers under the project are paying only assessments large enough to cover repayment to the Government for cost of construction and pumping assessments. On completion of the power development now under construction, the income from the sale of power will greatly reduce present expenses and probably provide a substantial surplus for improvements to the system.

Construction of the Roosevelt Dam was begun by the United States Reclamation Service in 1906 and completed in 1911. The reservoir has a total capacity of 1,637,000 acre-feet to the top of the 15-foot Taintor gates installed by the Salt River Valley Water Users' Association in 1923. The Roosevelt power plant develops 21,300 horsepower, having a maximum head of 228 feet. A power canal heading at a diversion dam 19 miles above the Roosevelt Dam increases the output of the plant at extremely low stages of the reservoir.

The Horse Mesa Dam is under construction about 16 miles below the Roosevelt Dam. It will create a reservoir of approximately 245,000 acre-feet capacity, and develop 40,000 horsepower with a plant operating under a head of 274 feet. This dam will be 306 feet high, arched in plan, with a radius ranging from 150 feet at the base to 250 feet at the top.

The Mormon Flat Dam is a regulating reservoir below the Horse Mesa Dam. Water released from Roosevelt and Horse Mesa dams for power purposes will be held in this reservoir until needed. A 10,000-horsepower hydroelectric plant is located at the Mormon Flat Dam to operate under a maximum head of 160 feet. These three plants utilize 662 feet of head. An additional hydroelectric plant to develop 15,000 horsepower on the east bank of Verde River opposite Mount McDowell is contemplated.

Water released from the storage reservoirs flows down the bed of Salt River to Granite Reef Dam, 32 miles east of Phoenix. Verde River, which drains an area of approximately 6,000 square miles, enters Salt River just above Granite Reef Dam. This dam is 1,000 feet long between abutments and 25 feet high above the stream bed. The water from the two rivers is diverted at Granite Reef into the Arizona Canal on the north side and the South Canal on the

south side of the river. The combined capacity of the two canals is nearly 4,000 second-feet.

A second diversion dam, located 6 miles east of Phoenix, supplies canals at lower levels by diverting water developed from return flow to the river below Granite Reef.

The seventh dam included among the project works is the Cave Creek Flood Control Dam, a concrete multiple-arched structure built jointly by the Salt River Valley Water Users' Association, County of Maricopa, city of Phoenix, State of Arizona, and the railroads and other interested parties. This dam, located about 23 miles north of Phoenix, is for protection against periodic floods in Cave Creek.

The Salt River Valley Water Users' Association operates four additional hydroelectric plants located at points where fall is available on the canal system in the valley. These plants have an aggregate actual capacity of 10,000 horsepower. The total actual capacity of all plants now operating (1926) is 31,000 horsepower.

There are 150 electrically operated pumping plants in operation on the project, providing both drainage and a reserve supply of irrigation water. The pumps will make available for irrigation between 300,000 and 400,000 acre-feet of pumped water annually in case of need.

The Roosevelt water conservation district comprises an area of 42,000 acres lying east of and adjacent to the Salt River irrigation project. Approximately 40,000 acres will be supplied with water. This district, under contract, pays the expense of lining certain canals of the Salt River irrigation project and is, in return, entitled to water saved from seepage by the lining. The district also has certain rights to flood waters in Salt River and at flood periods is entitled to a percentage of the flow. The amount of water from this source varies greatly as the flood periods in the river are variable, lasting from a few days to several months in different years. An average of about 20,000 acre-feet of water is reported yearly from this source. The water from these two sources is released at Granite Reef Dam and, at the point of diversion from South Canal, is lifted 50 feet to the Roosevelt Conservation High Line Canal from which it is distributed by gravity.

A third source of irrigation water supply is pumped underground water. The district has 26 electrically operated pumping plants with an average capacity of about 3 second-feet each, or a total capacity for a 300-day year of 39,000 acre-feet.

The water from these three sources amounts to approximately 130,000 acre-feet.

The cost of water to the farmer is estimated at $1.50 an acre-foot. The district has contracted for power to be furnished by the Salt River Valley Water Users' Association at a rate of 5½ mills a kilowatt-hour during periods when the association is developing 15,000 kilowatts. During years of low water, power development by the Salt River Valley Water Users' Association is low and the power is developed by steam, which is much more costly, with the result that the cost of water runs considerably above the estimated figure. This year (1926), the first year in which water has been available, appli-

cations were made for water for 18,000 acres. The season, following a long period of drought, has been more expensive than estimates for normal years, and the water has cost the farmer $2.50 an acre-foot.

Lands in the area outside the Salt River irrigation project and the Roosevelt water conservation district include about 13 square miles near Goodyear, owned and operated by the Southwest Cotton Co.; the Arcadia pumping district, an area of a few square miles near Camelsback Mountain; the high-lying lands in and about the Papago Saguaro National Monument; a strip adjacent to the Salt and Gila River channels; and several square miles of low-lying lands on both sides of Salt River and north of Gila River in the southwestern part of the area.

The land near Goodyear is irrigated with water obtained by pumping from the underground water supply. Many of the lateral canals are concrete lined. The lands of the Arcadia district are irrigated by water pumped from the Arizona Canal of the Salt River reclamation project. The high lands in and about the Papago Saguaro National Monument are not irrigated. The land along the river and the low land in the southwestern part of the area has a partial water supply in rights to waters of Salt River. At times when water is available from the Salt River irrigation project water is purchased from the Salt River Valley Water Users' Association and used on these lands.

On lands of the Salt River Valley area, irrigation is practiced by the border method, the furrow method, and, to less extent, by contour flooding. Such crops as alfalfa, pasturage, grain, and Bermuda grass are irrigated by the strip-border method. Most other crops are irrigated by the furrow method. Contour borders are used on a few of the more steeply sloping lands and on some of the lands that are being flooded in order to leach out detrimental quantities of soluble salts.

The borders are in many places 100 feet wide and many of the runs are one-fourth mile long. At the heads of the lands or rows, the soils are usually slightly lighter in texture, owing to the washing in of sand particles and the carrying away of fine particles by irrigation water. At the lower ends of the runs the opposite action is going on, and in many places for distances of more than 200 feet the texture is heavier on account of the deposition of fine sediment. Where one-fourth or one-half mile runs are used, the growth of vegetation is often uneven, being poor in the lower third of the run just above the point where the water backs up in the border or furrow. This uneven growth is caused by uneven distribution of water resulting from the length of the run. Runs of about one-eighth mile would result in a better distribution of water, more even penetration, and less silting at the ends of the runs. A point worthy of mention is the fact that pumped water penetrates the soil much faster than water from the reservoirs, probably owing to the fact that the calcium salts in the underground waters flocculate the soil particles and leave more pore space for water movement. Either a larger head of this water must be used to reach the lower end of the field or the land must be given a greater slope than is required for irrigation with reservoir waters. On lighter-textured soils it is

necessary to have comparatively narrow borders or furrows and shorter runs. As such soils also have comparatively lower water-holding capacity, more water must be applied at each irrigation and irrigations must be made at more frequent intervals.

DRAINAGE

The underground waters, owing to various characteristics of the substrata and relief, move at different rates of speed and in different directions. Following the lines of least resistance, they approach the surface in many places. Open drains have proved ineffective in relieving such conditions. The 150 pumps mentioned earlier in this report have a total capacity of 800 second-feet. These pumps, together with the necessary waste ditches that remove the underground water, form the very effective drainage works of the Salt River irrigation project. Some of the pumps are operated almost continuously, whereas others keep the water table lowered with comparatively little pumping. Most of the pumped water is emptied into canals and used for irrigation. Excess water from a large area south of Mesa is carried through an open drainage ditch southwest to Gila River, and the excess for the remainder of the project is disposed of in Salt and Gila Rivers. In 1918, in approximately 80,000 acres of project lands the water table was within 10 feet of the surface, whereas at present (1926) in less than 5,000 acres is it so high.

Lands under the Roosevelt conservation district are high lying, and at present none are affected by a high water table. The comparatively high location and the pumping plants make the danger of development of extensive poorly drained areas small, though some trouble may be experienced in the northeastern part of the area on the Pinal soils in which a hardpan layer restricts internal drainage.

The lands about Goodyear are drained by natural underground drainage. No irrigation water is applied to those about Papago Saguaro National Monument and there are no areas with a high water table. The strips lying adjacent to the Salt and Gila River channels, not included in the Salt River irrigation project, are of sandy texture and drain excessively to the river bed. The wider strips in the southwestern part of the area not included in the project lie at comparatively low elevations and parts of them have layers that greatly restrict adequate natural drainage. Large areas in these sections are affected by a high water table, and other parts have had a high water table in the past that has caused a high accumulation of alkali. An open drain, only partly effective, is located in the large area of nonproject lands on the south side of Salt River. Drainage and reclamation of these lands is futher discussed in the chapter dealing with alkali and in the soil type descriptions given elsewhere in this report.

ALKALI

In the processes of rock disintegration and decomposition and soil formation certain soluble salts are weathered out or freed from chemical combination, dissolved by percolating waters, and carried

in solution to various localities. Frequently these salts are deposited from solution in areas of restricted drainage by evaporation of the waters. This results in accumulations of alkali salts to such an extent that crop production is either precluded or affected to more or less degree.

Only a small proportion of the area covered by this survey is now affected by alkali, and only a small part of the alkali-affected land is considered seriously affected. Injurious alkali concentrations occur principally in rather flat low-lying areas which receive or have received seepage waters from higher-lying lands. The level of the ground water has risen nearly to the surface in such places and alkali has accumulated on or near the surface through evaporation. Although higher-lying lands are normally well drained and free from concentrations of salts, a few small areas are affected in places where dikes of rather impervious substrata have caused the ground water to approach the surface. In only a few places do the subsoils contain large amounts of alkali.

The salts most commonly found in the valley belong largely to the white alkali group. Three samples were sent to the University of Arizona where chemical analyses were made. Sample No. 1 was taken in sec. 9, T. 1 N., R. 1 E., where a very thin dark-brown surface crust was present, and although no irrigation water had been applied for months the ground continued moist. This sample was of the surface soil to a depth of 1 inch. It will be noted that a very large amount of calcium chloride, a deliquescent salt, was found in this sample. Sample No. 2 was taken in sec. 20, T. 1 N., R. 1 E., where a white crust from about one-fourth to one-half inch in thickness occurred on the surface. Sample No. 3 was taken in sec. 33, T. 1 S., R. 4 E., where patches of thin white surface crust underlain by 3 inches of deflocculated loose fluffy salt-impregnated soil material occurred. The thin crust and the deflocculated material were analyzed. Analyses of these samples are given in Table 5.

TABLE 5.—*Chemical analyses of alkali salts of soil examined in the Salt River Valley area, Ariz.*

(Parts per million)

Sample No.	Total soluble salts	Calcium	Magnesium	Chlorides	Sulphates	Carbonates	Bicarbonates
1	108,730	23,250	187	37,100	45	0	159
2	278,690	2,625	206	124,500	184	168	146
3	77,550	1,245	75	27,500	132	240	48

Included in total soluble salts are sodium chloride, the predominating salt in soils of the Salt River Valley area, sodium sulphate, and small amounts of sodium bicarbonate. In some localities large amounts of calcium chloride are present. This is a deliquescent salt which absorbs moisture from the atmosphere and keeps the surface soil moist, giving it a dark-brown color which is often erroneously attributed to black alkali. True black alkali, sodium carbonate, was found in only a few places in the Salt River Valley area. It is the most harmful of the alkali salts, and land affected by it is very hard

to reclaim. Where black alkali is present leaching and removal of the salts is promoted by applications of gypsum or sulphur which react with the carbonate, changing black alkali to white alkali. Owing to the general absence of black alkali. reclamation of alkali lands is comparatively simple.

In making the alkali map, which accompanies this report, four separations or grades were made, based on the degree of concentration of the alkali salts. These grades are as follows: (1) Alkali-free areas, (2) slightly affected areas, (3) moderately affected areas, and (4) strongly affected areas. The alkali-free areas are those which for all practical purposes are free from harmful alkali concentrations. They contain less than 0.2 per cent of alkali salts. In lands of this grade there is little danger of harmful concentrations developing except where unfavorable drainage conditions may develop and persist for considerable periods of time. The slightly affected areas are those which contain appreciable amounts of alkali salts, usually from 0.2 to 0.4 per cent, so distributed throughout the soil as to have little or no effect on the growth of ordinary crops. The moderately affected areas contain higher percentages of alkali, usually from 0.4 to 0.8 per cent, so distributed as to have some detrimental effect on the growth of crops. On lands included in this class many small spots are devoid of vegetation. In such spots the concentration, especially in the surface foot is often higher than given for the limits of this grade. The strongly affected areas contain such a large amount of alkali salts as to render them, in their present condition, unsuited to successful crop production. These areas generally have a concentration of more than 0.8 per cent in the 6-foot soil section. The differentiation into these grades was based on observations of vegetation and other visible conditions in the field supplemented by frequent tests of the soil material with the electrolytic bridge. Samples were taken in questionable localities, and tests for the percentage of total soluble salts present were made of the first foot of soil, of a composite of the second and third feet, and of a composite of the last 3 feet. The location of the sample, together with the results of the determinations are shown on the alkali map. The amount of salts present is shown in terms of percentage of soluble salts in the dry soil. The percentage in the surface foot and that of the average to a depth of 6 feet are shown in fractional form, the percentage of the first foot being represented by the numerator and the average of the 6-foot section by the demoninator of the fraction.

In all the slightly or moderately affected areas the concentration of alkali ranges widely from place to place. Adjacent spots in fields may contain very different concentrations and these differ in distribution through the 6-foot soil section. Where an appreciable amount of alkali is present, the vegetation is spotted. On irrigated lands this spotted condition is often due to poor leveling and the consequent uneven distribution and penetration of irrigation water. High spots which are not covered by water or covered by only a small amount provide ideal conditions for the concentration of alkali by capillary movement of water from the subsoil.

The most extensive strongly affected areas are found in the low bottom lands along Gila and Salt Rivers and in the low country

south of Tempe and east and southeast of West Chandler. Scattered small bodies occur along Agua Fria River, around Tolleson, and near Phoenix. The moderately and slightly affected areas are more widely distributed, the largest occurring in the southwestern part of the surveyed area and in the vicinities of Phoenix, Tolleson, Tempe, and West Chandler.

As heretofore stated, reclamation of alkali lands in the Salt River Valley area is comparatively easy, and the alkali content of the soils is being lowered on much of the irrigated land by reclamation measures which consist in lowering the water table to at least 10 feet below the surface and in flooding and holding water on the land so that the soluble salts are dissolved and carried out through the subsoil with the drainage water. In sandy or gritty soils of comparatively open structure through which water moves rapidly, complete reclamation may be effected in a very short period of time. In soils with tighter subsoils, the process is somewhat slower. In low-lying water-logged lands, the alkali concentration in the surface is, no doubt, slowly increasing. For these reasons it is recognized that the areas of alkali-affected lands shown on the alkali map are not permanent but may change considerably, both in extent and salt content from year to year.

SUMMARY

The Salt River Valley area includes 535 square miles or 342,400 acres in the south-central part of Arizona in the eastern part of Maricopa County. It occupies a broad, gently-sloping valley plain with minor included areas of hilly and mountainous lands and of river-bottom lands adjacent to Salt, Agua Fria, and New Rivers.

The area surveyed includes lands in the Salt River irrigation project, lands lying between the project and Salt and Gila Rivers, lands of the Roosevelt conservation district, lands around Goodyear, and lands irrigated by pumping in the Arcadia district.

Elevations of the irrigated lands range from about 900 to 1,350 feet above sea level. The area is drained by Salt and Gila Rivers and Paradise Wash, a tributary of Salt River.

The population of Maricopa County in 1920 was 89,576, of which 61 per cent was rural. Nearly all the farmers make their homes on the farms. Most of the farmhouses are supplied with wells, electric light and power, and telephones. Phoenix, the State capital, is the largest city in the area. The Salt River Valley area is traversed by the main east and west line and two branch lines of the Southern Pacific Railroad; a branch line of the Atchison, Topeka & Santa Fe Railway; and the southern highway leading from the west coast of the United States to the East. The valley has about 350 miles of paved highway. The principal market for produce is in the cities of the East, Middle West, and the west coast.

The climate is warm and arid. Temperatures vary considerably in different parts of the valley. The average frost-free season is 292 days at Phoenix and 269 days at the Mesa Experiment Farm.

Irrigation and farming were carried on in the valley by prehistoric tribes of Indians. In 1867 the first American whites started modern irrigation. Farm development grew continually and was

greatly accelerated in 1911, following the completion of the Roosevelt Dam on Salt River by the United States Reclamation Service. Construction of storage and hydroelectric power facilities and improvements have been inaugurated, principally by the Salt River Valley Water Users' Association, until at present the irrigation and hydroelectric power works, including those under construction, represent an investment of more than $23,000,000. The income from the sale of surplus power greatly reduces the cost of irrigation to the farmer. The irrigation water supply is diverted from Salt and Verde Rivers and is supplemented by pumping from underground sources.

The important crops grown in the area are cotton, alfalfa, citrus fruits, truck crops, pasture grasses, grains, sorghums, grapes, deciduous fruits, small fruits, and dates. Dairying and poultry raising are important in the area, and winter pasturing and feeding of livestock are sources of considerable income to the farmers of the valley.

Nearly all the land of the area is desirable irrigable land and is intensively farmed. The border and furrow irrigation methods of water distribution prevail. A comparatively large proportion of the farming operations is done with tractors. Rotation of crops is not practiced to an appreciable extent.

Farm labor is principally performed by Mexicans, supplemented in busy seasons by Indians from the Salt River and Gila Indian Reservations. The average size of farms is 40 acres. Agriculturally developed lands sell at prices ranging from $150 to $1,000 or more an acre, depending on the crop planted, improvements, and location.

The nonirrigable lands of the area are inextensive and include rough stony land and rough broken land. The irrigable soils are divided into two groups, soils derived from old transported alluvial deposits and soils derived from recently transported alluvial deposits. The profile development in the old soils varies from mature, with a firmly cemented lime carbonate hardpan, to less mature, with a fragmental lime-carbonate hardpan, nodular layers, or lime-carbonate mottles. The recent soils include principally brown or dark-brown medium or heavy textured, slightly stratified materials and a less extensive area of lighter-colored light-textured soils. Six soil series, represented by 23 soil types and 5 phases of types constitute the old transported soils in the area and 2 series, represented by 14 soil types and 8 phases, constitute the recent soils. In addition, 3 classes of miscellaneous materials were mapped.

Soils derived from old transported materials occur on the alluvial fans that slope from the adjacent hills or mountains. The recent soils occupy bottom land adjacent to rivers and streams and areas on the alluvial fans on which intermittent desert streams and flood waters have deposited later materials.

Adequate drainage has in the main been effected by a system of electrically operated pumps and a few open drainage and waste ditches. Only a small part of the area is poorly drained at present. Likewise, only a small part is affected by high accumulations of alkali, and parts of these affected areas are being reclaimed.

○

[Public Resolution—No. 9]

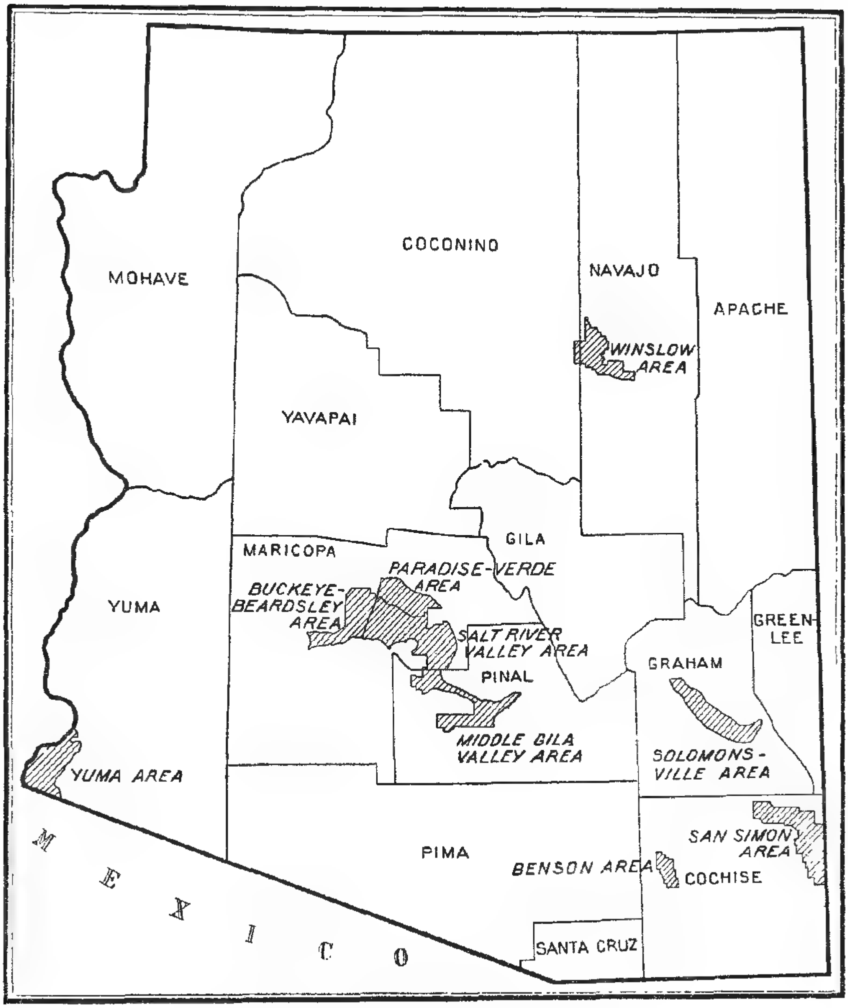
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second section, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided,* That in addition to the number of copies above provided for there shall be printed as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils, and on July 1, 1927, the Bureau of Soils became a unit of the Bureau of Chemistry and Soils.]



Areas surveyed in Arizona, shown by shading

Accessibility Statement

This document is not accessible by screen-reader software. The U.S. Department of Agriculture is committed to making its electronic and information technologies accessible to individuals with disabilities by meeting or exceeding the requirements of Section 508 of the Rehabilitation Act (29 U.S.C. 794d), as amended in 1998. Section 508 is a federal law that requires agencies to provide individuals with disabilities equal access to electronic information and data comparable to those who do not have disabilities, unless an undue burden would be imposed on the agency. The Section 508 standards are the technical requirements and criteria that are used to measure conformance within this law. More information on Section 508 and the technical standards can be found at www.section508.gov.

If you require assistance or wish to report an issue related to the accessibility of any content on this website, please email Section508@oc.usda.gov. If applicable, please include the web address or URL and the specific problems you have encountered. You may also contact a representative from the USDA Section 508 Coordination Team.

Nondiscrimination Statement

In accordance with Federal civil rights law and U.S. Department of Agriculture (USDA) civil rights regulations and policies, the USDA, its Agencies, offices, and employees, and institutions participating in or administering USDA programs are prohibited from discriminating based on race, color, national origin, religion, sex, gender identity (including gender expression), sexual orientation, disability, age, marital status, family/parental status, income derived from a public assistance program, political beliefs, or reprisal or retaliation for prior civil rights activity, in any program or activity conducted or funded by USDA (not all bases apply to all programs). Remedies and complaint filing deadlines vary by program or incident.

Persons with disabilities who require alternative means of communication for program information (e.g., Braille, large print, audiotape, American Sign Language, etc.) should contact the responsible Agency or USDA's TARGET Center at (202) 720-2600 (voice and TTY) or contact USDA through the

Federal Relay Service at (800) 877-8339. Additionally, program information may be made available in languages other than English.

To file a program discrimination complaint, complete the USDA Program Discrimination Complaint Form, AD-3027, found online at http://www.ascr.usda.gov/complaint_filing_cust.html and at any USDA office or write a letter addressed to USDA and provide in the letter all of the information requested in the form. To request a copy of the complaint form, call (866) 632-9992. Submit your completed form or letter to USDA by:

(1) mail: U.S. Department of Agriculture
Office of the Assistant Secretary for Civil Rights
1400 Independence Avenue, SW
Washington, D.C. 20250-9410;

(2) fax: (202) 690-7442; or

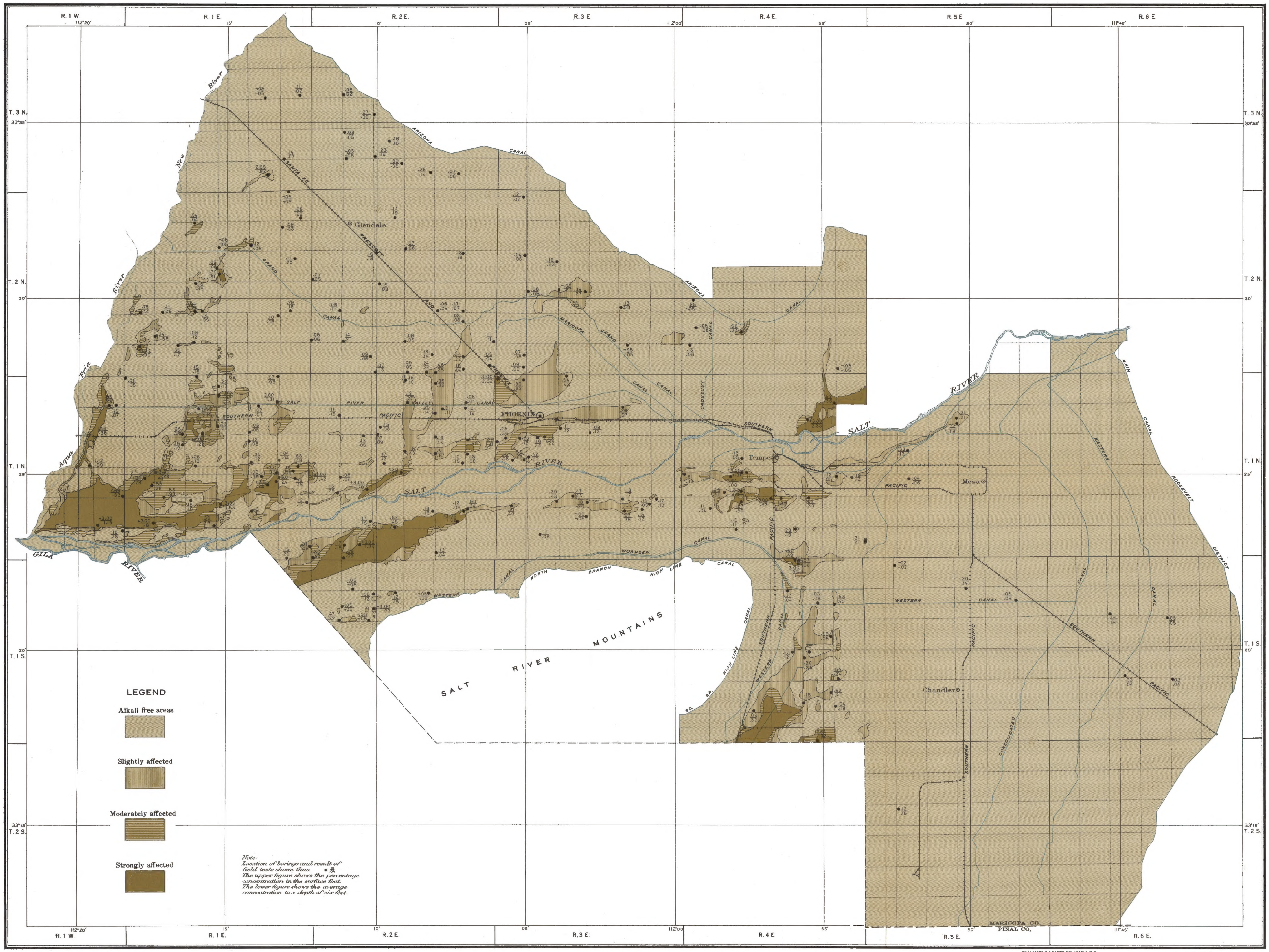
(3) email: program.intake@usda.gov.

USDA is an equal opportunity provider, employer, and lender.

U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF CHEMISTRY AND SOILS
HENRY G. KNIGHT, CHIEF
A. G. McCALL, CHIEF, SOIL INVESTIGATIONS
CURTIS F. MARBUT, IN CHARGE SOIL SURVEY

ALKALI MAP
SALT RIVER VALLEY AREA
ARIZONA

UNIVERSITY OF ARIZONA
AGRICULTURAL EXPERIMENT STATION
J. J. THORNBER, DIRECTOR
G. E. P. SMITH, HEAD, DIVISION OF AGRICULTURAL ENGINEERING



Macy H. Lapham, Inspector, District 5
Alkali surveyed by W. G. Harper, in charge, F. O. Youngs, and A. T. Strahorn, U. S. Department of Agriculture, and S. W. Armstrong, University of Arizona

Scale $\frac{1}{125000}$
1 ½ 0 1 2 3 4 5 Miles

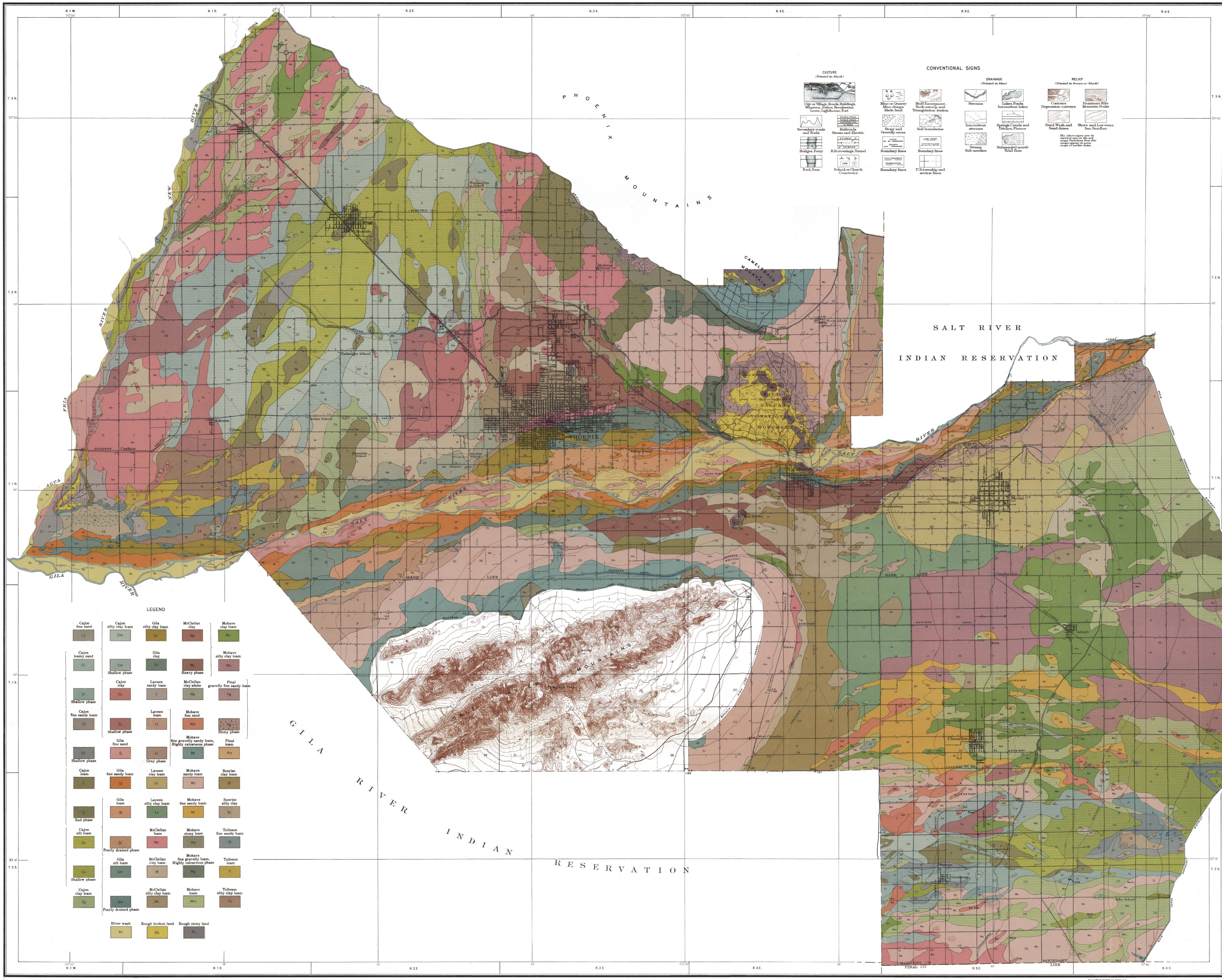
WILLIAMS & HEINTZ CO. WASH. D.C.

Field Operations
Bureau of Soils
1926

U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF CHEMISTRY AND SOILS
HENRY G. KNIGHT, CHIEF
A. G. McCALL, CHIEF, SOIL INVESTIGATIONS
CURTIS F. MARBUT, IN CHARGE SOIL SURVEY

SOIL MAP
SALT RIVER VALLEY AREA
ARIZONA

UNIVERSITY OF ARIZONA
AGRICULTURAL EXPERIMENT STATION
J. J. THORNBER, DIRECTOR
G. E. P. SMITH, HEAD, DIVISION OF AGRICULTURAL ENGINEERING



Macy H. Lapham, Inspector, District 5.
Soils surveyed by W. G. Harper, in charge, F. O. Youngs, and A. T. Strahorn, U. S. Department of Agriculture; and S. W. Armstrong, and H. C. Schwalen, University of Arizona.

BASE MAP IN PART FROM U. S. GEOLOGICAL SURVEY SHEETS

Scale 1/62500
Contour interval 25 feet.
Datum is mean sea level.

Field Operations
Bureau of Soils
1926